GUIDE FOR THE IDENTIFICATION OF RARE, THREATENED OR SENSITIVE BRYOPHYTES IN THE RANGE OF THE NORTHERN SPOTTED OWL, WESTERN WASHINGTON, WESTERN OREGON, AND NORTHWESTERN CALIFORNIA.

A Cooperative Project of the Eugene District, USDI Bureau of Land Management; Siuslaw National Forest, USDA Forest Service; The Nature Conservancy; and the Northwest Botanical Institute.

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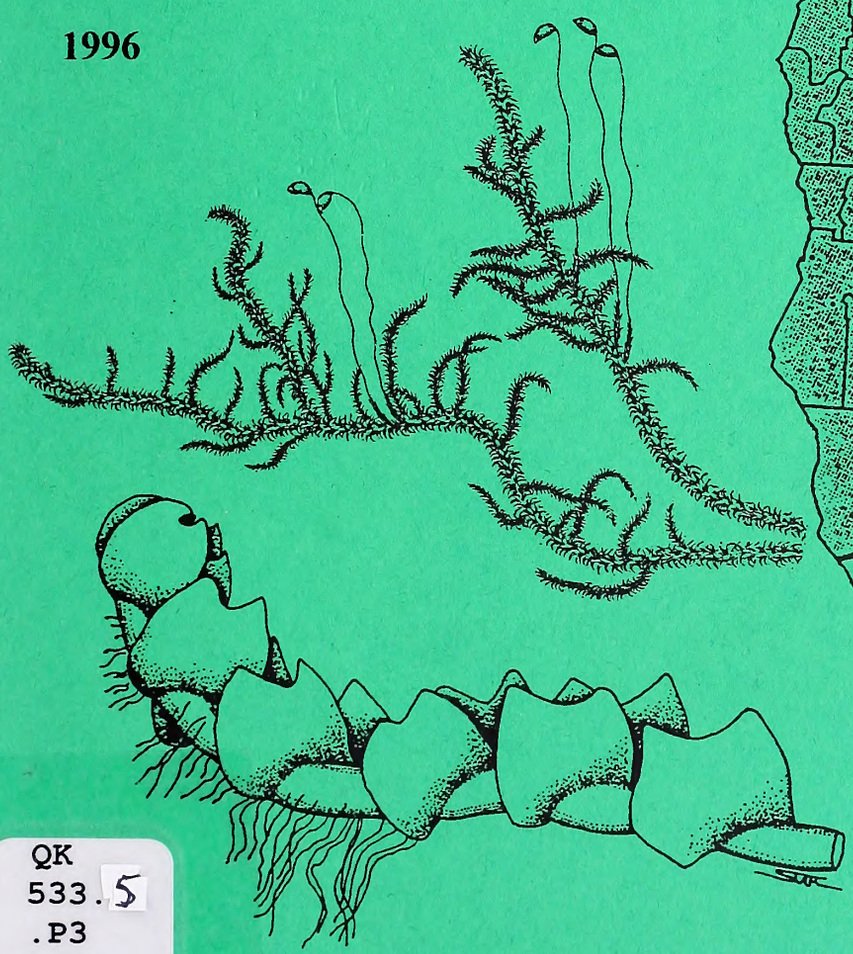
1996



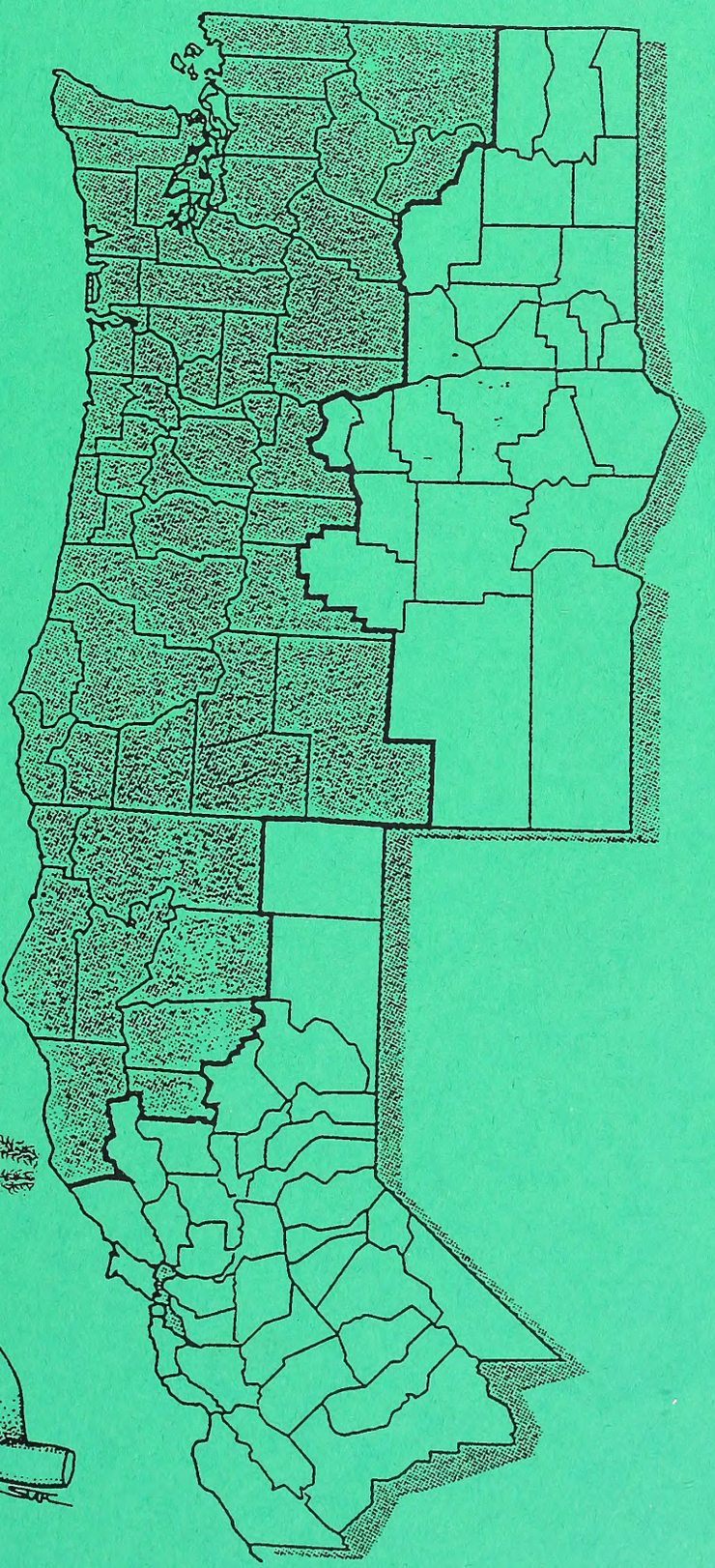


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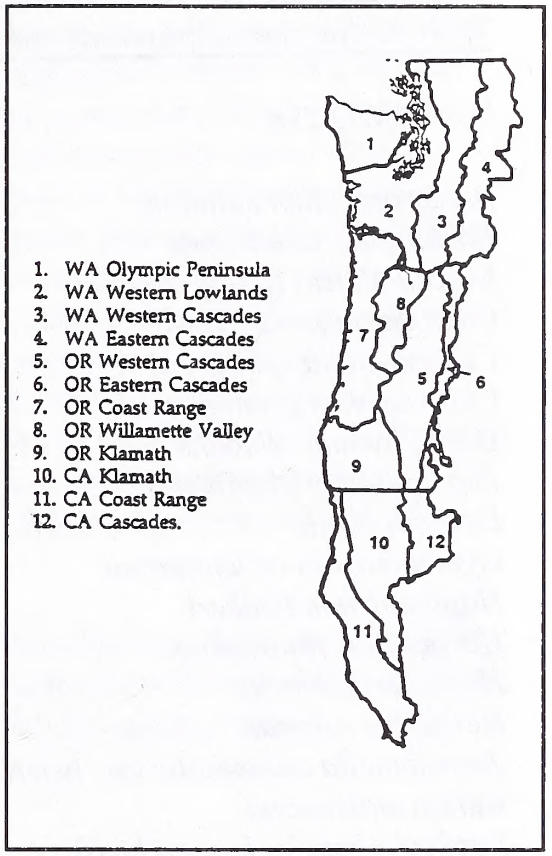
TABLE OF CONTENTS

PART I. INTRODUCTION

Purpose and scope of guide

We wrote this guide to help people identify the sensitive or rare species of mosses and liverworts occurring within the range of the northern spotted owl. Geographic coverage extends from the Pacific coast to the east slope of the Cascade Range, and from northwestern California to the Canadian border.

Our primary objective was to facilitate identification of rare species not listed in readily-available manuals. About one-third of the liverworts and mosses treated in the guide cannot be found in standard references for our area. These species were either undescribed at the time the books were written, or had not yet been found in our part of the world. We have collected the scattered references for these taxa, extracted descriptions and illustrations, and put them all in one location for ease of access.



Geographic area covered by this guide. From Record of Decision, 1994.

This guide describes 35 species of liverworts and 36 species of mosses (Table 1). These include all those listed in Table C-3 of the Record of Decision (USDA Forest Service and USDI Bureau of Land Management 1994b), those listed by the Oregon Natural Heritage Program (1995) as occurring within the range of the northern spotted owl, and five listed in the SAT report (Scientific Analysis Team 1993) that were dropped from later lists. An official list of rare bryophytes for the state of Washington is not yet available.

The list of bryophyte taxa in Table C-3 of the Record of Decision (ROD) was the end product of several analyses designed to assess the long-term viability of biota associated with late-successional and old-growth forests, under a variety of management scenarios. The first list was published in the SAT report by the Scientific Analysis Team (1993), subsequently revised in the FEMAT report by the Forest Ecosystem Management Assessment Team (1993), and finalized in the Final Supplemental Environmental Impact Statement (USDA Forest Service and USDI Bureau of Land Management 1994a) and the Record of Decision.

These analyses were remarkable because they included not only vertebrates and vascular plants, but numerous invertebrates, fungi, lichens, mosses and liverworts (Lesher et al. 1994). This was the first time that non-vascular plants and invertebrates had been considered at this scale in forest management issues in the Pacific Northwest. A team of regional experts was assembled to compile a list of species that met defined criteria of association with late-

Table 1. Species of liverworts and mosses treated in this guide.

LIVERWORTS

Anastrophyllum minutum
Barbilophozia barbata
Barbilophozia lycopodioides
Calypogeja sphagnicola
Cephaloziella spinigera
Chiloscyphus gemmiparus
Diplophyllum albicans
Diplophyllum plicatum
Douinia ovata
Gymnomitrion concinnatum
Haplomitrium hookeri
Harpanthus flotovianus
Herbertus aduncus
Herbertus sakuraii
Jamesoniella autumnalis var. *heterostipa*
Kurzia makinoana
Lophozia laxa [= *L. marchica*]
Marsupella condensata
Marsupella emarginata var. *aquatica*
Marsupella sparsifolia
Metzgeria temperata
Nardia japonica
Plagiochila satoi
Plagiochila semidecurrens var. *alaskana*
Porella vernicosa var. *fauriei*
Preissia quadrata
Ptilidium californicum
Radula brunnea
Scapania gymnostomophila
Scapania obscura
Schofieldia monticola
Sphaerocarpos hians
Tritomaria exsecta
Tritomaria exsectiformis
Tritomaria quinquedentata

MOSSES

Andreaea schofieldiana
Antitrichia curtipendula
Bartramiopsis lescurii
Brotherella roellii
Bruchia bolanderi
Buxbaumia piperi
Buxbaumia viridis
Calliergon trifarium
Campylopus schmidii
Conostomum tetragonum
Crumia latifolia
Encalypta brevicolla var. *crumiana*
Encalypta brevipes
Funaria muhlenbergii
Helodium blandowii
Iwatsukiella leucotricha
Limbella fryei
Orthodontium gracile
Pleuroziopsis ruthenica
Pohlia sphagnicola
Polytrichum sphaerothecium
Polytrichum strictum [= *P. juniperinum* var. *affine*; *P. alpestre*]
Racomitrium aquaticum
Racomitrium pacificum
Rhizomnium nudum
Rhytidium rugosum
Schistostega pennata
Scouleria marginata
Splachnum ampullaceum
Tayloria serrata
Tetraphis geniculata
Tetraplodon mnioides
Trematodon boasii
Tripterocladium leucocladulum
Triquetrella californica
Ulota megalospora

successional and old-growth forests. The team then rated the species' viability under themanagement options. Originally, 122 species of liverworts and mosses were considered for rating. Of these, 106 were considered closely associated with old-growth forests, and the rest were dropped from further consideration because they were not closely associated with such forests. Of the 106 remaining species, 79 were assigned to 13 habitat groups, based upon apparent similarities in habitat preference and presumed responses to the management options. Five of these were rated individually because they did not fit readily into species groups, or were too poorly known. Twenty-two were rated individually because of their status as rare species, and another 16 were subsequently dropped because they were not found to be closely associated with old-growth forests. Finally, the 22 rare species, and one common but putative "keystone" species (*Antitrichia curtipendula*), were selected for listing in Table C-3 of the Record of Decision. These 22 species, plus those tracked in the study area by the Oregon Natural Heritage Program, and 5 species identified in the Record of Decision as requiring protection buffers (*Buxbaumia piperi*, *Buxbaumia viridis*, *Rhizomnium nudum*, *Schistostega pennata* and *Ulota megalospora*), are the ones treated in this guide (Table 1).

Some of the text in this guide was borrowed directly from the bryophyte sections in the SAT, FEMAT, and FSEIS (Appendix J2) reports, most of which was written originally by John Christy. These sources contain much more detail about the viability rating process.

Format and authorship of guide

The guide provides a brief review of the biology and ecology of liverworts and mosses in our area, guidelines for studying, collecting and curating specimens, keys, descriptions and illustrations for identifying each species, range maps, glossaries, and an annotated bibliography of useful references. Species are listed alphabetically, rather than by habitat or substrate group. Note that descriptions of genera are relatively sparse in the species treatments. When a user is not familiar with a particular genus, he/she should work backwards through the keys to gain an appreciation for the diagnostic features of genera.

The keys and treatments for liverworts were written by David Wagner, and those for mosses were written by John Christy. The balance of the guide was a collaborative effort.

Terminology and nomenclature

The guide was written with the thought in mind that the typical user is a practicing botanist reasonably familiar with the technical language of higher plants, but still a beginner in bryology. An effort has been made to avoid jargon and keep the language consistent throughout the guide. Whenever possible, we avoided using technical terms in the species descriptions. Those that could not be avoided are defined in the illustrated key to the liverworts (Part IV), or in the glossary at the end of the moss treatments (Part VII). Other terms may be found in the glossaries of Lawton (1971), Flowers (1973) or Ireland (1982).

Botanists follow traditional rules of nomenclature that are designed to promote consistency. When more than one name has been used for a species, one of these is generally considered an "accepted" name, and the alternate names are called synonyms. Some species have no synonyms, some have many. In this guide, we have dealt with the issue of synonyms by citing only those used in references generally available in the Pacific Northwest. For liverworts, these references are Crum 1991, Frye & Clark 1937, Frye & Clark 1943, Frye & Clark 1945, Frye & Clark 1946, Frye & Clark 1947, Müller 1954, Müller 1957, Pojar and MacKinnon 1994, Schuster 1953, Schuster 1966, Schuster 1969, Schuster 1974, Schuster 1980, Schuster 1992, Schuster 1992a, Smith 1990, and Vitt et al. 1988. For mosses, these are Lawton (1971) and Flowers (1973). Except for a few recent changes, scientific nomenclature follows Stotler and Crandall-Stotler (1977) and Anderson et al. (1990).

Very few standardized common names are available for bryophytes. There's good reason to refer to these as "vernacular names," because it emphasizes that common names are parochial, based on a regional language, as English, Japanese, Norwegian or Kwakwaka'wakw. Janice Glime and her colleagues have presented a series of articles in *Evansia*, compiling published vernacular names that have been used for mosses around the world. For the Pacific Northwest, the only reference that offers English names consistently is Pojar and MacKinnon (1994). Most of Pojar and MacKinnon's names were coined for that publication. Likewise, we invented most of the English "common names" for this guide. They will be helpful to those who find English names a mnemonic bridge to Latin names. It should be remembered, however, that they will be sensible only to those who use them in this region, and people are free to choose whatever they desire for an English or other vernacular name. The currently accepted Latin names, however, should always be used in technical writing and other formal reports.

Similar species

Discussions of look-alikes in the species treatments are based on the presumption that users are already familiar with the most common genera. Comparisons are made with the common species that resembles it most, usually other species in the same genus. By the time a botanist can recognize about twenty genera of leafy liverworts on sight, he or she is generally able to work independently, using appropriate literature, to identify a large proportion of random collections. It is intended that the discussions here would allow such a botanist to correctly identify most of these species. In order to help a beginner focus on a limited set of twenty appropriate genera, the following list has been developed (Table 2).

Table 2. Twenty prominent genera of leafy liverworts in the Pacific Northwest

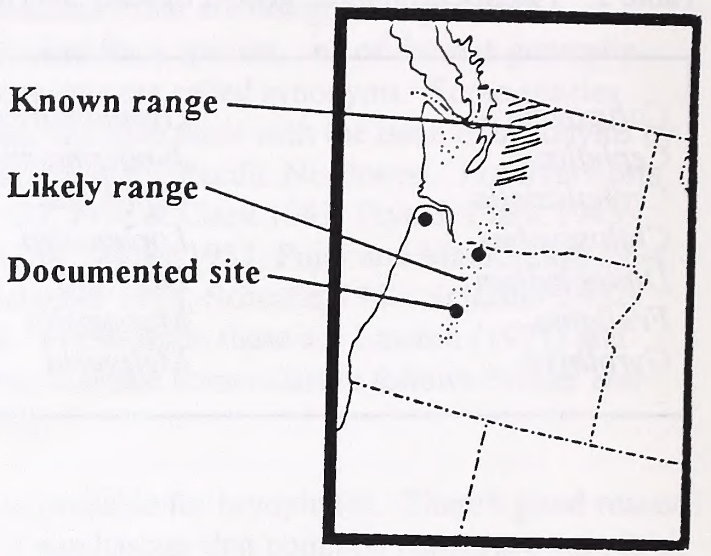
Calypogeia	*Gymnomitrion*	*Nardia*
Cephalozia	*Jungermannia*	*Plagiochila*
Cephaloziella	*Lepidozia*	*Porella*
Chiloscyphus	*Lophocolea*	*Ptilidium*
Diplophyllum	*Lophozia*	*Radula*
Frullania	*Marsupella*	*Scapania*
Gyrothyra	*Metzgeria*	

Rare or sensitive status

Schofield (1994) defined a rare bryophyte as "one that shows a restricted geographic range, usually of less than five square kilometers, or one that is known from fewer than five localities, even when these localities are widely distant from each other." This definition of rarity is essentially the same as that developed by The Nature Conservancy, used by all Natural Heritage Programs and Conservation Data Centers to rank global and state/provincial rarity of organisms or plant communities (Master 1991, Andrus et al. 1992, Slack 1992). Inherent in the interpretation of rarity in bryophytes is the problem of poorly collected areas. What looks rare on paper may actually be abundant in the field, and its apparent rarity is only an artifact of undercollecting. For this reaseon, some of the species listed in this guide are probably more common than we think.

The "status" notation used in the species treatments of this guide indicates the rare or sensitive status of the taxon, as listed by various regional agencies. **FEMAT** refers to the report of the Forest Ecosystem Management Assessment Team (1993). **FSEIS** refers to the spotted owl Final Supplemental Environmental Impact Statement's Appendix J2 (USDA Forest Service and USDI Bureau of Land Management 1994a). **FWS SoC** refers to the U.S. Fish and Wildlife Service listing as Species of Concern, authorized by the federal Endangered Species Act, as published in the *Federal Register*. **ODA C** refers to listing as a candidate by the Oregon Department of Agriculture, authorized by the Oregon Endangered Species Act. **ONHP** refers to the Oregon Natural Heritage Program's biennial listing of rare, threatened and endangered plants and animals (Oregon Natural Heritage Program 1995). **ROD** refers to the Record of Decision's Table C-3 (USDA Forest Service and USDI Bureau of Land Management 1994b). **SAT** refers to the report of the Scientific Analysis Team (1993).

Distributions, maps and endemism



The maps show distributions of each species, based on literature reports and herbarium records. We have no doubt overlooked some records, but the maps should give the user a general idea of the species' likely range. We used three types of symbols to represent distribution: (1) **cross-hatching** -- widespread and common, with localities too numerous to map individually, (2) **dots** -- known localities for individual collections, a few of which remain unverified, and (3) **stipples** -- expected range, showing areas where the species is likely to occur, and where new populations should be sought; it does *not* imply continuous distribution.

Many of the bryophyte species in the Pacific Northwest are circumboreal, occurring interruptedly around the northern fringe of North America and Eurasia. Such species frequently extend southward in mountainous regions where cool, moist forests prevail, or where subalpine and alpine vegetation is developed. Species such as *Herbertus aduncus* and *Haplomitrium hookeri* fall into this category, reaching their southern limit in our region. Other species, such as *Plagiochila satoi* and *Nardia japonica*, have a northern Pacific distribution. These are found in northern parts of eastern Asia, and are distributed in an arc northward through Alaska, and then southward to the Pacific Northwest.

In this guide, the only liverworts endemic to western North America are *Chiloscyphus gemmiparus*, *Schofieldia monticola*, and *Sphaerocarpos hians*. Endemic mosses treated here are *Andreaea schofieldiana, Brotherella roellii, Bruchia bolanderi, Buxbaumia piperi, Encalypta brevicolla* var. *crumiana, Limbella fryei, Racomitrium pacificum, Scouleria marginata, Trematodon boasii, Tripterocladium leucocladulum, Triquetrella californica* and *Ulota megalospora*.

Illustrations

The illustrations used in the guide were reproduced from published sources, or are original material provided by David Wagner. For the original illustrations, it was agreed by the authors and the agency representatives that the federal government has unlimited copying privileges for the original material in the form presented here, but that the author/artist retains copyright ownership of the original drawings. The illustrations from published sources are used with permission of the publishers and authors, as listed in the acknowledgements.

Conservation Issues

Although this guide is intended to convey the current state of knowledge about the rare or sensitive species of bryophytes in the study area, the overall appreciation of these plants in the landscape is severely limited because they have been ignored for so long by so many field workers. The nomenclature and classification of these plants, despite some currently unresolved issues, is actually much clearer than our understanding of their distribution, habitat, and ecological function. Many data are missing, and much territory is completely unexplored bryologically. For this reason, the comments offered in the "conservation issues" section for each species treatment should be recognized as speculation, based on our own experience. Any recommendations must remain open to further discussion, inviting regular review and revision, based on integration of additional new information.

Acknowledgements

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We would appreciate any and all comment and criticism on the guide, to improve future editions.

PART II. BIOLOGY AND ECOLOGY OF BRYOPHYTES IN STUDY AREA

Hornworts, liverworts and mosses, known collectively as bryophytes, are small, green, nonvascular, spore-bearing plants that have evolved a wide array of species well adapted to nearly every habitat on earth. There are between 8,000 to 9,000 species of mosses and about 6,000 species of liverworts in the world (Vitt et al. 1988). About 150 species of liverworts and 450 species of mosses occur within the range of the northern spotted owl, 20% of which are endemic to western North America or the Pacific Northwest.

Among sexually reproducing populations of bryophytes, genetic diversity has been found to be comparable to that of vascular plants (Stoneburner et al. 1991). Although bryophytes can reproduce by means of spores, many species never or rarely produce them for one reason or another. Many taxa in our area reproduce only by vegetative means, either through fragmentation of leaves or stems, or by means of special asexual propagules. Virtually any cell, from any part of a plant, can regenerate a new plant if conditions are favorable, creating clonal populations. Genetic diversity would thus be expected to be lower in bryophyte populations limited to vegetative reproduction, but in most cases, it has been found still to exceed that required for evolutionary change, despite the potential for inbreeding (Shaw 1991). This inbuilt genetic polymorphism seems to maintain viability, even in isolated, disjunct populations. Therefore, it appears that landscape "corridors" are not needed to maintian gene flow in bryophytes, but they are nevertheless useful aids in dispersal.

Bryophytes and old-growth forests

There is a growing body of literature describing the close association of some bryophyte species to old-growth forests in North America and Europe, and the many threats faced by them due to diminished habitat. Norris (1987) found nine of 128 bryophyte species of late-successional redwood forests to be absent from stands that had been clearcut 100 years earlier, and 22 other species were reduced in abundance in the younger stands. McCune (1992) observed significant differences in species composition and biomass of epiphytic bryophytes in stands aged 95, 145 and 400+ years. He noted a marked reduction of bryophytes in the younger age classes. Elsewhere in the Pacific Northwest, beyond the range of the spotted owl, Lesica et al. (1991) found significant differences in bryophyte communities between late-successional and managed second-growth forests. They found that seven of the 11 species of leafy liverworts seen in the stands occurred only in old-growth, which had the greatest amount of rotting wood substrate required by these plants. Studies in Europe (e.g., Söderström 1988; Laaka 1992) indicate that late-successional forests serve as refugia for bryophyte species that no longer occur in, or cannot colonize younger stands, because of air pollution, acid rain or short rotations in managed forests.

Habitat groups and their ecology

Species of bryophytes occur fairly consistently in specific habitats, with some overlap determined by latitude, elevation and microclimate. Species of mosses and liverworts can be grouped by habitat or substrate as a means of classifying different components of the ecosystem in our region.

Aquatic, submerged. Aquatic habitats for bryophytes range from submerged rock and wood in perennially cold, clear water, to organic muck in water with low or no flows. Many of these habitats may dry up seasonally, and most species involved can tolerate seasonal drying. In arid areas, aquatic bryophytes have been collected from irrigation ditches, vernal pools and water troughs. Bryophytes can be a major component of stream ecosystem, providing year-round habitat for a wide array of algal species, invertebrates and fish. They are a perennial source of organic material for downstream use, and of all riparian vegetation they are probably the most efficient filters for trapping sediments and small organic material. Plants are frequently abraded by waves, ice and other debris.

Decaying wood, wet or dry. Bryophytes in this group occur consistently on decorticated to well-rotted logs and stumps. They are best developed in old-growth, cool to moist forest stands in deep shade, particularly on stream terraces and floodplains. The group contains the highest proportion of liverworts in our area. Species diversity is richest in old-growth stands. Many of the liverworts are mycorrhizal (During and van Tooren 1990), and it is significant that most of the liverworts occurring in old-growth are restricted to decaying wood. It is also noteworthy that most liverworts are restricted to late-successional stands where decaying wood is most abundant (Spies and Franklin 1988). Liverworts may play an important role in decomposition of coarse woody debris, of which these forests have some of the highest biomass in the world. The logs are extremely important sites for vertebrate and invertebrate habitat, nitrogen fixation, mycorrhizal activity, seedbeds and retention of water. The group is very sensitive to changes in light level and moisture. Removal or thinning of the canopy increases light levels, raises temperatures and desiccates the understory, all of which adversely affect these species. Their existence also depends on continued inputs of rotten wood in various decay classes and diameters for their required substrate.

Epiphytic. This group has been well studied in our area (see reviews in Nadkarni 1984 and Peck et al. 1995), and also in the northern Rocky Mountains, where many Pacific Northwest coastal species occur (Lesica et al. 1991). Epiphytic bryophytes are best developed in shaded, cool and humid forests, where they may be abundant on both trees and understory shrubs, especially in riparian areas and on stream terraces. Most conifers support epiphytes, and hardwoods such as red alder and bigleaf maple often support rich floras that differ from those on conifers. Epiphytic bryophytes act as sponges, absorbing and retaining both moisture and nutrients leached from lichens and foliage in the upper canopy, and slowly releasing them to the forest floor (Nadkarni 1984; Brown and Bates 1990; Bates 1992).

Humus and duff. These species occur on shaded duff and humic soil in moist to relatively dry forests. They typically occur at midslope, on benches or in concave microtopography. Although poorly investigated, bryophytes on the forest floor are suspected to be associated with mycorrhizal fungi, and play a role in nutrient cycles in the forest. Most species are common and widespread. Steele (1978) found that species of moss occurring in mesic forest associations were limited to those associations, but those of drier forest associations spanned several different associations.

Peatlands, including fens and bogs. Although a number of palynological studies have been done in peatlands in our area, the bryoflora has been neglected until recently (Campbell 1973; Seyer 1979; Wilson 1986; Frenkel et al. 1986). Most reports have focused on sites in the Cascade Range. Bogs form when peat builds up high enough to inhibit upward capillary movement of groundwater that has been in contact with mineral soil. In these cases, precipitation becomes the only source for nutrients available to plants growing on the peat. In contrast, fens are rich in nutrients because of calcareous soils or bedrock, and because peat does not build up high enough to inhibit the effects of enriched groundwater. A distinctive group of bryophyte species occurs in each wetland type, all of which are circumboreal in distribution. These habits have not been explored adequately in our area.

Rocks. A distinctive array of bryophyte species occurs on rocks, tolerant of extremes in heat, cold and drought. Moisture regimes range from dry to seasonally wet, to splash zones in small to large fast-flowing streams, or in the spray zone of rapids and waterfalls. In arid areas the bryophyte flora may be composed exclusively of rock-dwelling species. Calcareous rocks have a characteristic bryophyte flora, although many common rock-inhabiting taxa also occur on calcareous rocks. Such outcrops are uncommon in our area, and few bryophytes have been collected from them. Species diversity is much greater on undisturbed rocks and outcrops than in road cuts and clearcuts. In exposed areas at all elevations, most bryophyte cover occurs on shaded or otherwise protected rock faces where moisture persists longer (McCune 1977; Nash et al. 1977; Spence 1981; Lavin 1982). They may also be subject to nitrogen enrichment at bird roosts, which can limit bryophyte growth on rock faces. Those along streams may be abraded by waves, ice and other debris. Rock-dwelling species adapted to shade in forest stands, such as at the base of undisturbed outcrops, are replaced by xerophytic species when the forest canopy is removed.

Soil. These species occur on exposed or shaded mineral soil at all elevations. Dry and perennially wet soils usually have very different floras. Dry sites at lower to middle elevations develop drought-tolerant, short-lived assemblages that are replaced by others within a year or two. Habitats include roadcuts, agricultural fields, trail banks, roadsides, root balls of windthrown trees, landings and clearcuts. Wet sites are often associated with organic muck, rotten logs, and gravel and rocks. Habitats include edges of lakes and streams, shrub swamps, active earth slumps, margins of avalanche tracks, seepage areas and the bases of talus slopes, often with late-lying snow beds. Primary succession on recently-disturbed soil includes many opportunistic species that rapidly colonize sites, stabilize soil and enhance invasion by other cryptogams or vascular plants. Some high-elevation sites may have long-

lived associations, rather than those composed of early-successional species. Near timberline, they occur on glacial moraines and outwash, especially where protected by rocks in areas where snow may accumulate (Spence 1981). Soil-dwelling species may harbor nitrogen-fixing bacteria that enrich soil fertility. They stabilize soil by trapping particles, reduce wind erosion, help maintain soil moisture, and may enhance seed germination. In spite of the widespread occurrence of soil habitat, distribution of species may be sporadic and unpredictable.

Threats to bryophytes

Air pollution. Epiphytic species at the edge of stands, and bryophytes on exposed summits and ridgelines may be affected by air pollution. These habitats, where many bryophytes supplement their water budget by intercepting fog, have the highest concentration of rare disjunct species in the Pacific Northwest. Air pollution is a mounting threat within the region. Hallingbäck (1992) described how air pollution has caused epiphytic *Antitrichia curtipendula* and *Ulota* to disappear from Sweden, as well as stunting growth and causing a decline in sexual reproduction. Good airshed management would minimize risks from air pollution, but most of these activities occur on non-federal land, and improvements may only be possible through legislation.

Fire and fire suppression. Fire, or lack of fire, influences nearly every bryophyte habitat group except aquatic and splash zone species. It influences bryophytes in both positive and negative ways. Under historical fire regimes, bryophytes in fire-prone habitats were routinely burned or heat-killed on lower tree trunks, rocks and soil. Much of the biomass and cover of bryophytes seen today in these habitats are an artifact of fire suppression. Development of bryophytes would have been best in old, unburned forests, on rocks and cliffs above normal flame heights, and in wetlands. The shade-loving bryophyte communities of forested rock outcrops probably developed only after long periods of canopy stability and lack of fire. Reintroduction of fire could impact some of these species of very old, stable sites that have expanded their range as a result of fire suppression.

Grazing and agriculture. Bryophyte habitat groups most affected by these activities are dry soil, wet soil, humus and duff, and peatlands. Grazing and agriculture in the Pacific Northwest have been ongoing on a large scale since the 1860's. Impacts include cultivation, trampling and churning of the substrate, and artificial drainage. Cumulative losses probably have been greatest for the wet soil species occurring on floodplains, where farming and livestock impacts have been concentrated. Riparian areas today are in such poor condition that ecologists have difficulty in determining what vascular plants, not to mention bryophytes, grew in the understory. Peatlands, because of the availability of water, have also been subject to livestock trampling and drainage projects that can affect hydrology for many decades (Bursik and Moseley 1992a, 1992b; Bursik 1993). They are best protected by fencing to prevent trampling and water pollution.

Water pollution, sedimentation and diversion. Dams, including small hydropower projects, and diversion of water for agriculture can decimate bryophyte diversity locally, by altering hydroperiod and water temperatures. Sedimentation can decimate aquatic species or those in the splash zone. Generally, good watershed management, with stream buffers and riparian retention, will benefit the aquatic and splash zone group. Good water quality cannot be assured on non-federal lands except through legislation.

Logging. Habitat groups affected by logging include decayed wood, epiphytic, humus and duff, aquatic, and wet soil. The decayed wood group is particularly dependent on old-growth characteristics. Removal of the canopy increases light levels and temperature, and ensuing desiccation leads to replacement of these species by a suite of other more drought-tolerant bryophytes. Logging of old-growth, and large-scale conversion to younger stands will cause an inevitable decline in those species of bryophytes restricted to or best developed in old-growth (Lesica et al. 1991). Although mosses in the understory can disperse effectively by spores (Stoneburner et al. 1992), many species in old-growth forests in the Pacific Northwest never or rarely produce spores. Dispersal in such cases is limited to vegetative propagules that travel only short distances, carried by wind, invertebrates, or mammals adapted to life the understory of these forests (Kimmerer and Young 1995). Old-growth stands, once serving as sources of inoculum for nearby burned or clearcut areas, will be too few and too far apart to perform this function adequately if they continue to disappear. A forest landscape managed on short rotation will not have stands of sufficient age to be receptive to inoculum of these species, even if it were available in abundance. Fragmentation of canopy from logging can diminish the capacity for moisture retention in stands, and reduce the ability of epiphytes to develop much biomass (Norris 1990). Protection of old-growth stands and canopy shading, decommissioning roads on stream terraces, maintenance of stream buffers, green tree and log retention, as well as watershed protection, are all important to maintain bryophyte diversity.

Commercial and scientific collecting. At current levels, commercial harvest of mosses and liverworts impacts both epiphytic and decayed wood substrate groups. Peatland species may also be at risk if a market develops in our area for sphagnum moss. Harvest may have serious long-term implications for processes such as mineral cycling, moisture retention in rotting logs, and seedbed availability for vascular plants. In our area, studies are underway to identify the effects of commercial harvest. Scientific collecting of highly restricted species at particular sites may also cause declines. In Part III of this guide, we provide guidelines for ethical scientific collecting.

Quarrying, road construction and mining. These activities impact rock and peatland substrate groups. Quarrying, road construction and mining of limestone deposits destroy habitat for rock-dwelling species. Commercial harvest of peat and rotten wood for use as soil amendments has a catastrophic effect on many liverwort and peatland species dependent on these substrates.

PART III. GENERAL BACKGROUND TO THE STUDY OF BRYOPHYTES

Bryophyte taxonomy

Liverworts, hornworts and mosses are green plants that share many characteristics, but also exhibit many differences. There are many ways to view differences and similarities among bryophytes, so that authors do not agree on how to classify them. This disagreement is what keeps taxonomy alive. The details about any classification hierarchy, and the arguments for one system versus another, are subjects vitally important to evolutionary scientists. A practicing field botanist may find such discussions fascinating, but it is not necessary to be conversant with these in order to deal with the day to day issues of conserving biodiversity and ecosystem management. The keys and descriptions presented in this guide do not reflect any particular classification scheme, as the playing field keeps changing.

Depending on their point of view, some authors place the three groups in separate divisions (phyla): Marchantiophyta for the liverworts (called Hepatophyta in some references), Anthocerotophyta for the hornworts, and Bryophyta for the mosses. These workers point out that liverworts, hornworts and mosses are no more related to one another than the ferns are to the flowering plants. More traditional authors believe that the similarities between the three groups outweigh their differences, and they place them all in one division, the Bryophyta. Under this scheme, the division is subdivided into three classes, Hepaticae for liverworts, Anthocerotae for hornworts, and Musci for mosses. However one chooses to classify them, these three groups of plants are distinct from all others, and exhibit an independent evolutionary lineage dating back to the Devonian, some 400 million years ago (Schofield 1985). The divisions and classes are divided into various orders and families, again depending on the taxonomic concepts of the author.

The ranks in a taxonomic hierarchy that concern a field botanist are mainly family, genus and species. In bryophytes, as in vascular plants, family relationships are usually fairly clear, once one becomes familiar with the characteristics of various genera. However, there is still disagreement about the family placement of some genera or species, and some genera hop from one family to another in different reference works. For this reason, family concepts are ignored in this guide. Fortunately, what makes a genus and a species among the bryophytes is as intuitively reasonable as what makes a genus and species of flowering plants. A botanist who can easily tell one kind of flowering plant from another should be able to learn how to tell one moss or liverwort from another quite as readily. Just as some groups of flowering plants are more difficult than others--sedges and composites require serious concentration to distinguish--so are some bryophytes more difficult to sort out. What we refer to as "taxonomic problems" are most often encountered in the difficult groups. Inscrutable nature will never relieve us of these problems. The competent field botanist quickly learns what is easy, and studies these closely, so that energy spent on the difficult species is most sharply focused. The fastest way to trigger memory is with visual cues.

This guide has been prepared with its major emphasis on the vegetative features of liverworts and mosses. No hornworts are treated here. The idea is that a user should be able to

work with a random collection, as often as not likely to consist of sterile plants. Unlike the situation in mosses, sporophytes of liverworts are ephemeral and mostly not very useful for everyday identification. On the other hand, the reproductive structures associated with the gametangia of liverworts are quite distinctive and very important as taxonomic characters. A field botanist needs to be able to recognize the presence of these structures so that suitable material is gathered for further study in the laboratory.

Morphology and Terminology

There are two general types of plant body among the liverworts: *thalloid* and *leafy*. Thalloid liverworts (and all hornworts, not treated in this document) grow as flat, usually fleshy ribbons of tissue, forking regularly or irregularly. The plant body is referred to as a *thallus* rather than a shoot. The larger thalloid liverworts, such as *Marchantia aquatica* and *Conocephalum conicum*, are the most noticeable liverworts in our flora, since they are so dramatically different from other bryophytes. Untrained observers often confuse them with robust foliose lichens, such as species of *Peltigera*. Note that there are no thalloid mosses and no leafy hornworts. Among the thalloid liverworts there are two main groups in our area: those with differentiated tissue in the thallus, and those whose thallus is composed mainly of a single type of cell. Thalloid liverworts with complex tissue, the *Marchantia*-type, tend to be larger and are exclusively terrestrial, with greatest diversity developed on mineral soils that are seasonally desiccated. Thalloid liverworts with simple tissue, the *Metzgeria*-type, are generally smaller, mostly restricted to substrates that are perpetually moist, and include many species which are epiphytic or grow on organic substrates.

Mosses also have two general types of plant body: *acrocarpous* and *pleurocarpous*. Akin to the differences between thalloid and leafy liverworts, it is mainly a difference in growth form and the placement of the capsules, but one may also generalize about ecology of the two groups. Acrocarps are usually upright plants, usually single shoots that may be branched or unbranched, with the capsules produced at the tips of the shoots. Pleurocarps are usually trailing or pendent, branched shoots, with capsules produced at the tips of side branches. Ecologically, acrocarps usually grow in more exposed sites, and tend to be pioneer species with drought-resistant adaptations such as papillae, lamellae and awns. In contrast, pleurocarps tend to occur in cool, moist habitats, although most are capable of dehydration during the dry season. There are, of course, annoying exceptions to these rules, but most species fit nicely into one or the other category.

Leafy liverworts are like mosses in that they have a cylindrical stem with three rows of leaves produced along the stem. However, moss stems usually twist as they grow, so that the rows of leaves spiral around the stems, and the leaves appear to radiate in all directions. In liverworts the leaves remain in strict ranks down the stem. The arrangement of leaves in distinct rows up and down the stem is one of the main features which we use to tell a leafy liverwort from a moss in the field. There are only a few exceptions. In the moss genus *Fissidens* the leaves are in two distinct rows on opposite sides of the stem, an arrangement called distichous. These and most other distichous mosses, however, have a distinctly thickened midrib (costa), as occurs in

most mosses, while leafy liverwort leaves *never* have a midrib. In *Fontinalis*, the leaves are in three rows, but it is not likely to be mistaken for a liverwort. It shows another feature characteristic of mosses: the leaves are widely spaced and well-differentiated from the stem. Most leafy liverworts have leaves closely spaced on the stem or are clearly mere enations, or flaps of tissue projecting outward from stem tissue and of similar texture and appearance. The general difference is somewhat subtle, but easily learned and recognizable in the field with a hand lens.

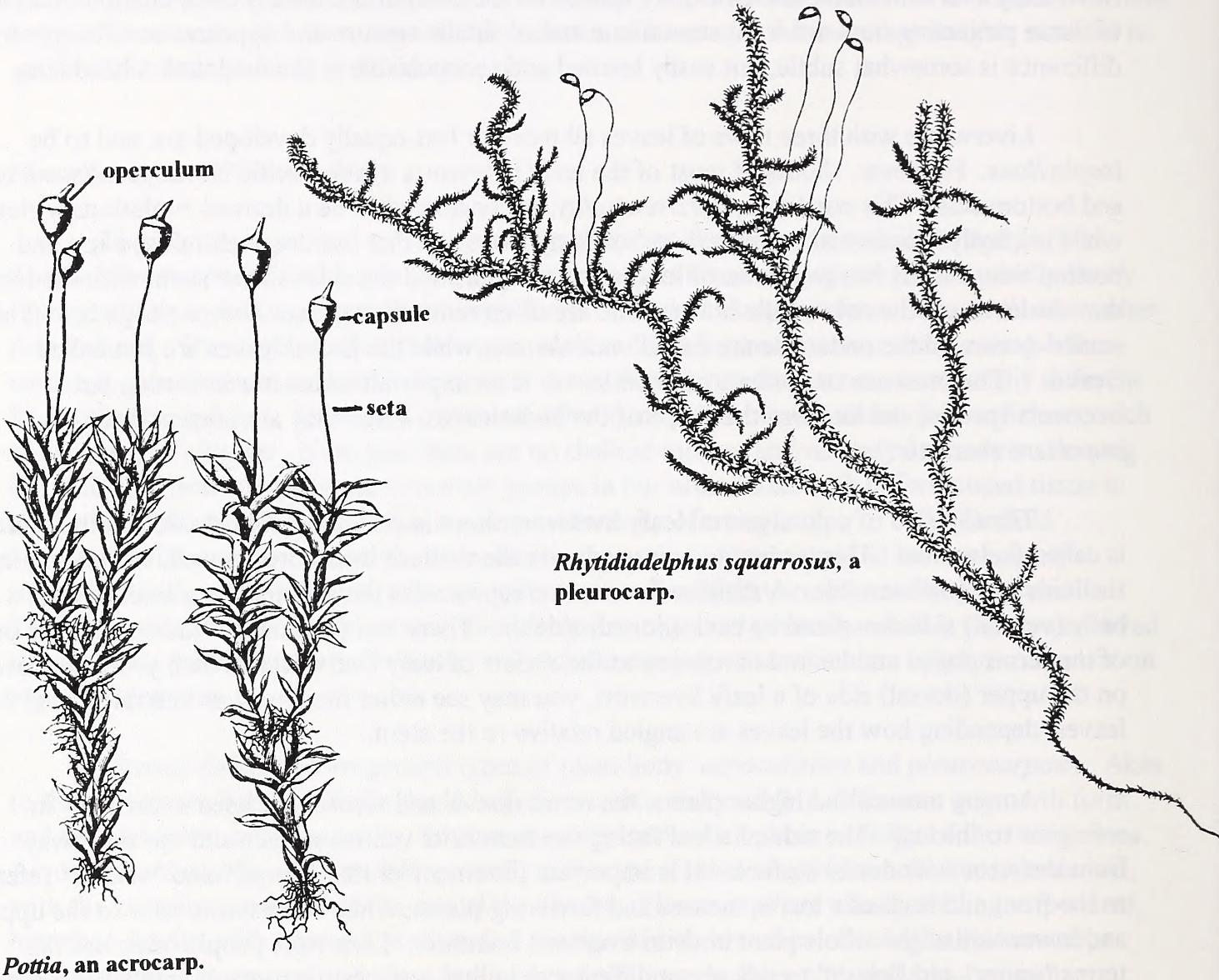
Liverworts with three rows of leaves all more or less equally developed are said to be *isophyllous*. However, shoots of most of the leafy liverworts of the Pacific Northwest have a top and bottom side. This condition, *dorsiventrality*, is considered to be a derived evolutionary state, while isophylly is ancestral or "primitive." A leafy liverwort that has dorsiventrality, a top and bottom side, usually has two rows of leaves wrapping around the sides of the stem, with the result that the leaves of the row on the bottom side are often reduced in size or absent altogether. These smaller leaves on the underside are called *underleaves*, while the lateral leaves are just called "leaves." The presence or absence of underleaves is an important character in sorting out liverwort species, and likewise the shape of the underleaves, when they are present, is an important character.

The top side of a dorsiventral leafy liverwort shoot is called the *dorsal* side and the bottom is called the *ventral*. This terminology is used with the thallose liverworts as well, but among the thalloids it is quite sensible. A thallose liverwort creeps across the ground like a snake, with its belly (ventral) side down and its back (dorsal) side up. There can be some confusion with the use of the terms dorsal and ventral in relation to the shoots of leafy liverworts. When you look down on the upper (dorsal) side of a leafy liverwort, you may see either the dorsal or ventral side of the leaves, depending how the leaves are angled relative to the stem.

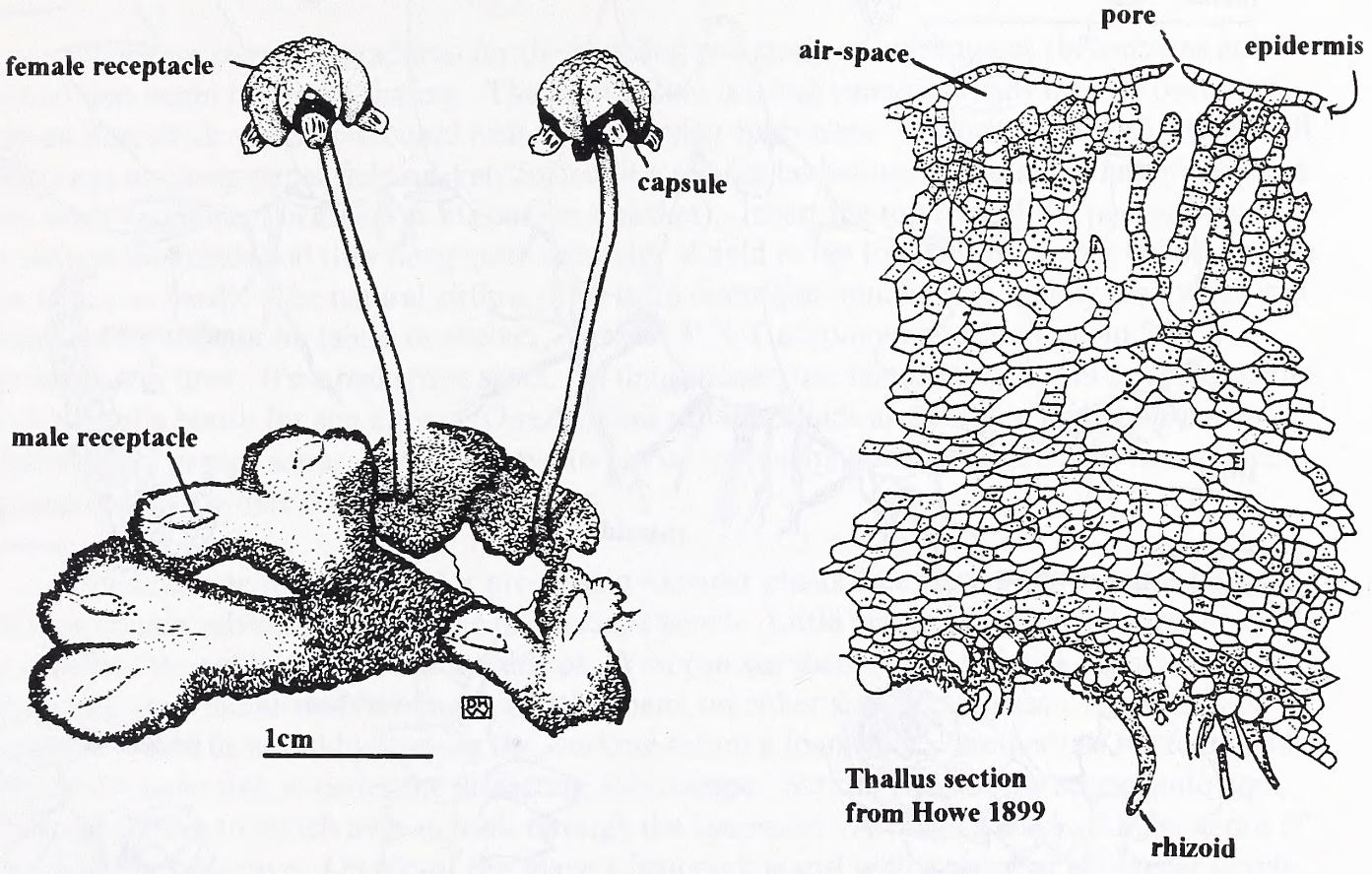
Among mosses and higher plants, the terms *dorsal* and *ventral* are used exclusively in reference to the leaf. The side of a leaf facing the stem is its ventral surface and the side away from the stem is its dorsal surface. It is important to remember that "dorsal" and "ventral" refer to the front and back of a leaf in mosses and flowering plants, while these terms refer to the upper and lower side of the whole plant body in liverwort literature. Liverwort people often use the terms "upper" and "lower" to talk about differences in leaf surfaces (fortunately rarely necessary), to avoid confusion with dorsal and ventral. Academic specialists, again seeking to avoid ambiguity, use the terms "antical" and "postical" in place of "dorsal" and "ventral," to refer to upper or lower margins of leaves, or upper or lower side of the shoot.

There are a few terms for reproductive structures used with liverworts that will be unfamiliar to the botanist used to working with higher plants and mosses. The sex organs are the same, antheridia and archegonia. In thallose liverworts the female sex organs are usually surrounded by a rim of tissue called an involucre while the antheridia are usually embedded in pits. These are often aggregated into separate structures called receptacles. The archegonium of the order Metzgeriales (commonly thallose liverworts with solid tissue) expands into a fleshy tube called a calyptra. (Note that the calyptra of mosses is a very different kind of structure, a hat on the capsule, even though it also develops from archegonium tissue.)

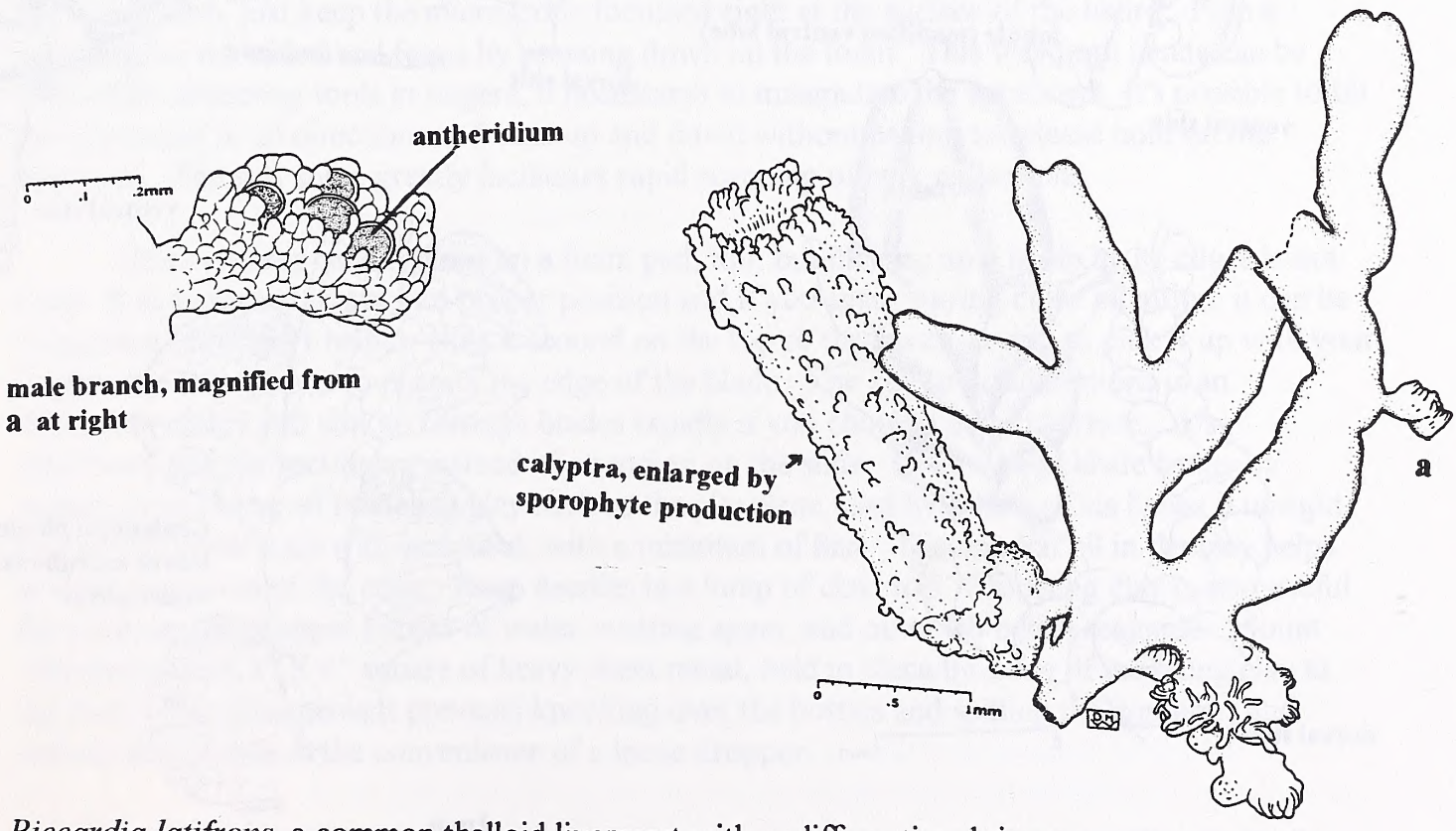
Following are illustrations for each growth type of moss and liverwort, the parts named with terms used in this document. Many other terms are explained in the generic key for liverworts, or in the glossary following the species treatments for mosses.



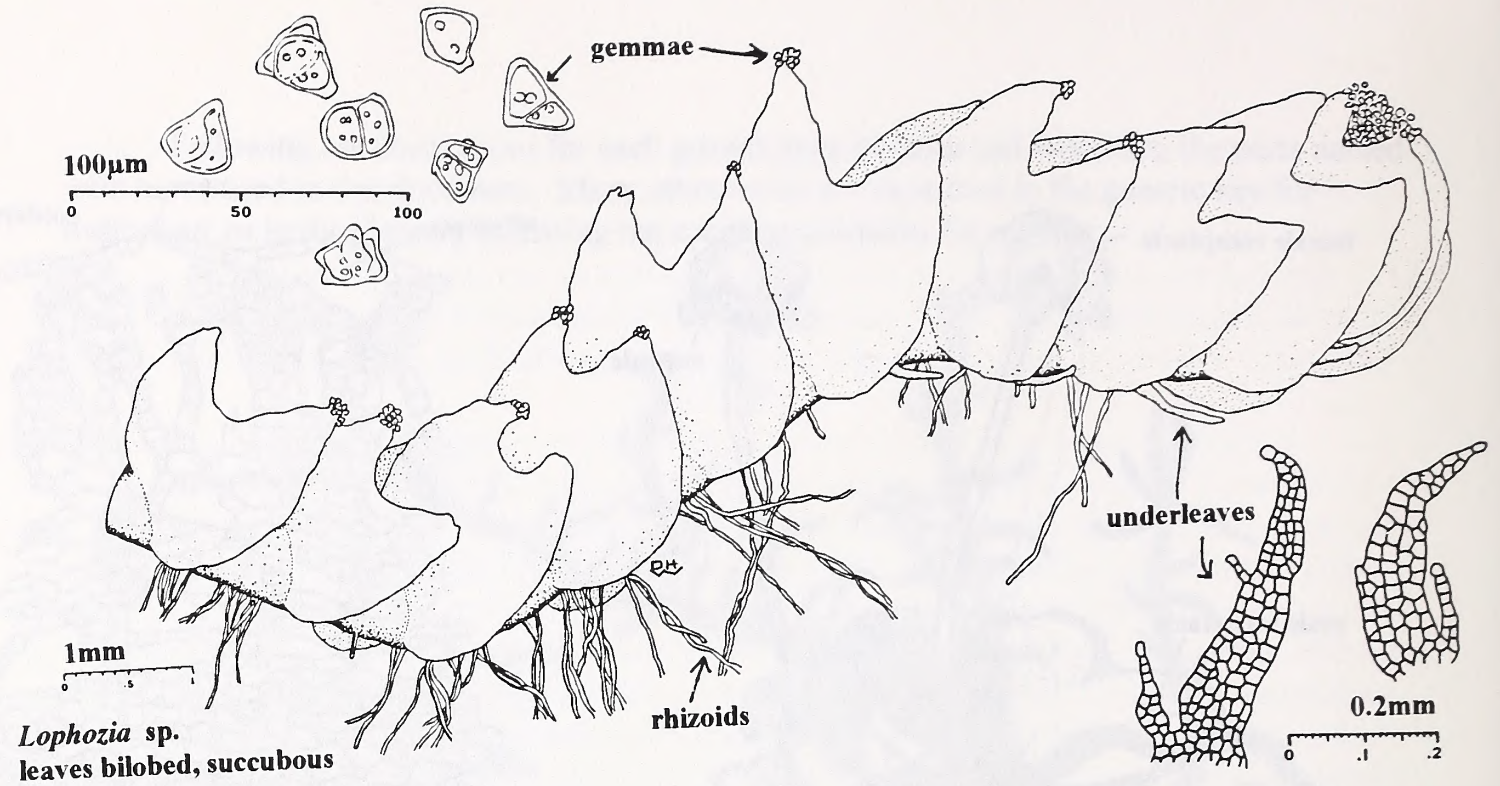
Acrocarpous and pleurocarpous mosses. On left, an acrocarp (*Pottia*), with capsules produced at the apex of the stem. On right, a pleurocarp (*Rhytidiadelphus squarrosus*), with capsules produced on lateral shoots. From Grout 1903.

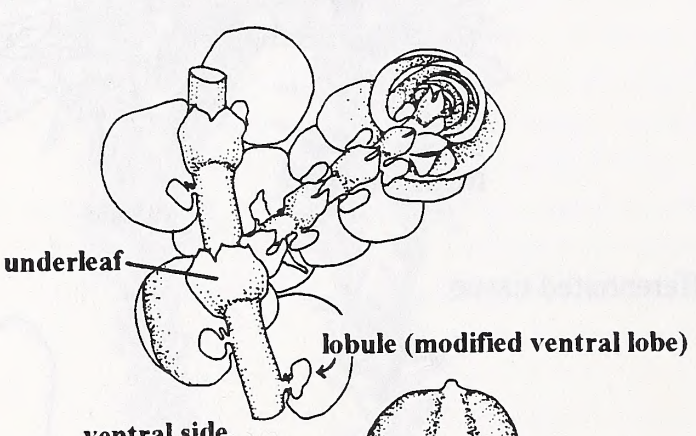


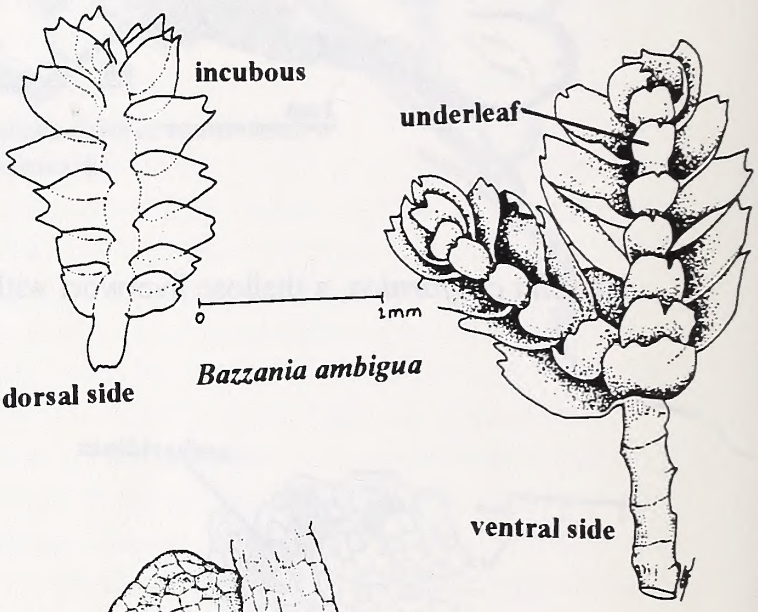
Asterella californica, a thallose liverwort with differentiated tissue.

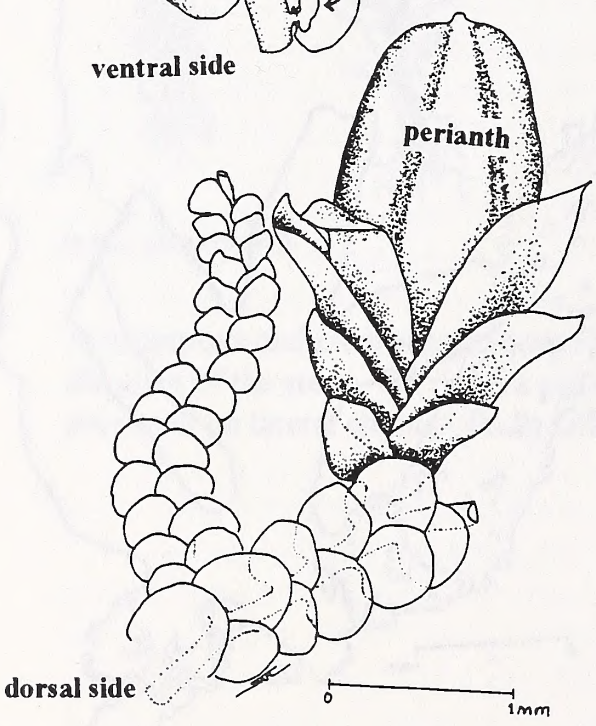


Riccardia latifrons, a common thalloid liverwort with undifferentiated tissue.

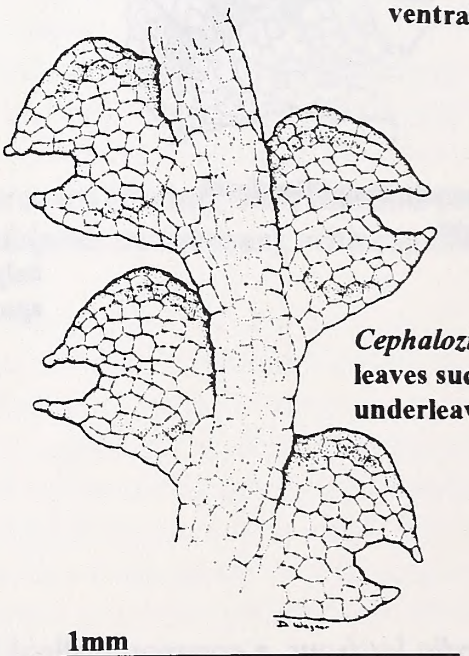








Frullania californica



Cephalozia pleniceps
leaves succubous, no underleaves

Lab hints

There are some lab practices for the handling and study of cryptogams (bryophytes and lichens) that might be worth sharing. The most recent is using venetian blinds located over heat sources (forced air vents, baseboard heaters) for drying specimens. It works well with either kraft paper bags or cheap paper field packets folded like regular herbarium packets (the latter preferred since what you collect in a packet fits best in a packet). Insert the top fold of the packet between the slats of the blinds and they hang quite securely. A fold in the top half of a paper collection bag slips in just as easily. The natural airflow dries them overnight, much more rapidly than when wet specimens are left out on tables or shelves. A blind 4' X 4' accommodates more than 50 specimens at a time. It's a real space saver. In the summer, use blinds hung from the eaves on the south side of a house for sun drying. One can find suitable blinds at a bargain price by frequenting neighborhood garage sales. You only have to put up with neighbors being quizzical about blinds hanging in places where there are no windows.

Polyurethane foam, useful for processing vascular plants (see Herbarium News 3:63. 1983), is equally advantageous on the microscope bench. Little pieces of half-inch foam, 3" X 5", are excellent for holding slides and coverslips. You can see them easily and pick them up easily by pressing your thumb and forefinger into the foam, on either side of the glass. Thousands of coverslips would be saved by keeping the working set on a foam pad. Another use for foam pads, again of the same size, is under the dissecting microscope. Set the body of the scope quite high, so you don't have to hunch over to look through the eyepieces. Arrange a stack of foam about 3" high under the objective. On top of this place a firm cork board with a piece of millimeter graph paper taped to the board for direct measurements. Instead of raising the stage by fussing with the focussing knob, just keep the microscope focussed right at the surface of the board. Plop a specimen on the board and focus by pressing down on the foam. This way both hands can be used (with dissecting tools in fingers, if necessary) to manipulate the specimen. It's possible to tilt the specimens in all directions and scan up and down without having to release hold on the specimen. The soft stage greatly facilitates rapid scanning of bulk collections.

One can keep razor blades on a foam pad, too, but picking up a blade by its edges is not ideal. It is awkward to get into proper position and if you aren't paying close attention, it can be dangerous. It doesn't help to slide it around on the top of the bench, trying to pick it up with your fingernails. The idea is to protect the edge of the blade. The key to good sections is an immaculate edge and you go through blades rapidly if you chop on a hard surface. Use elderberry pith for sectioning instead of chopping on the slide. Keep a keen blade handy by parking it in a lump of modeling clay such as the plastilene used by artists. This keeps it upright so you can pluck it up with one hand, with a minimum of fuss. The mineral oil in the clay helps prevent corrosion of the edge. Keep needles in a lump of clay, too. Modeling clay is also useful for propping up dropper bottles of water, wetting agent, and other lab bench reagents. Mount each bottle on a 2" X 2" square of heavy sheet metal, held in place by a rim of modeling clay at the base. This arrangement prevents knocking over the bottles and spilling the contents, and permits indulgence in the convenience of a loose dropper.

Slide mounts can be saved for future study by putting a drop of glycerine at the edge of the coverslip and allowing it to replace the water overnight. After all the water has evaporated, tack down the corners of the coverslip with drops of clear fingernail polish. It is not a permanent mount, but if handled carefully will last many years.

Be prepared for being tricked by wet and dry specimens. Liverworts and mosses have an annoying habit of looking radically different when dry and wet. If you are used to working with dried herbarium material, you may find it difficult to name species in the field if it has rained recently, or if plants are wet from dewfall. A wet plant may look completely different from a dry one, and in the field you may think that an old fried (or foe) is something new to you. When you open up the packet after the specimen has dried, the mystery specimen has miraculously transformed into something horribly ordinary, and you'll wonder what you had for breakfast that day!

If your material has dried out, you will need to wet it before you can dissect and mount leaves for microscopic examination. Dry plants are slow to rehydrate, and a faster way to wet them is to dip them in hot water. For this purpose, some people keep a dish of water over a hot plate or alcohol lamp, and use forceps to dip whole shoots in the water. Wetting agents also work well. The most popular, Aerosol OT by Fisher Chemical Co., is now hard to find from retail suppliers. Try Photo-flo or a similar product from photography stores. Wetting agents should not be used with dry but still living liverworts because they destroy oil-bodies in liverworts. Thalloid liverworts shrivel badly when they dry and never fully recover their natural form when re-wetted. They can easily be preserved in liquid by storing in tightly capped bottles in a mixture of equal parts of denatured ethyl alcohol (sold in hardware stores as shellac thinner) and white vinegar.

Observing oil-bodies in liverworts

Undoubtedly, the most unfamiliar character for identifying species of liverworts is the oil-body. Botanists whose training is typical of that available in this country will never have heard of oil-bodies. Even among contemporary liverwort specialists, attention to oil-bodies has been sporadic, with some assiduous in recording data and some making only casual notes. That oil-bodies are very useful taxonomic characters is undisputed; the pertinent issue is that special attention must be given to capturing this information.

The most important thing to remember is that oil-bodies are present only in living cells. When a sample of a liverwort is allowed to dry out, its cells die and the oil-bodies dissipate. There are some species which have oil-bodies persistent in dried specimens. Species with persistent oil-bodies are few and so this trait is used as a diagnostic feature. Having information about oil-bodies available on most species, however, means that specimens must be examined while they are alive and fresh from the field. When budgeting time for field work with liverworts, it is essential to fold in one or two days of immediate follow-up lab work, within the following week, lest the collections dry or decompose.

The procedure is simple: prepare a microscope slide by mounting leaves in a drop of water under a coverslip. Skill in detaching and handling liverwort leaves is acquired by practice only; verbal explanations fail. The leaves should be viewed with magnification equivalent to a 40x objective and a 10x eyepiece on a compound microscope. Oil-bodies, if present, stand out as very distinctive cell components. Chloroplasts are always present in living cells of liverworts, and can be used as components for comparison. Sometimes, however, the chloroplasts will be so dense that the oil bodies are obscured. Scanning other leaves on the slide preparation might yield clearer observations.

The first thing to observe is the appearance of the oil-bodies. A thorough discussion of oil-bodies is beyond the scope of this document; an excellent review is available in Schuster's manual (Schuster 1966). At the least, notice their color and if the oil-bodies are transparent or made up of globules or granules. Ideally, one should measure the size of the oil-bodies with a micrometer but in this area it seems sufficient to compare oil-body size with chloroplast size. The relative size is clearly taxonomically consistent. Note whether the oil-bodies are smaller than, equal to, or larger than the chloroplasts. Count the number of oil-bodies in a random sample of ten or more cells and record the average and range.

Size standards for liverworts

Providing an internally consistent standard for terms used to describe size has been difficult. Knowing whether something is small, medium, or large for a liverwort is of obvious importance, but past literature has depended on the reader already having an appropriate sense of size based on experience with the group. A large *Gymnomitrion* would make a small *Marsupella*, yet the two genera have species which overlap in size range. In order to establish consistency with size terms, the liverwort section uses the following, arbitrary scale with five terms.

SIZE STANDARDS FOR SHOOT WIDTH OF LEAFY LIVERWORTS

minute	<0.5 mm
small	0.5 - 1.5 mm
medium	1.5 - 2.5 mm
large	2.5 - 4 mm
robust	>4 mm

Although arbitrary, and without any widely accepted standard, these values are close to those generally used for the terms by liverwort people. They are generally suitable for leafy liverworts. Thallose liverworts are mostly larger and a different scale would be needed to reflect the usage of size terms in current literature. This has an impact on the Key to Genera (PART IV). In the key, statements about relative sizes are often somewhat generalized, and do not always conform to the standardization of terms in the individual species treatments. If size is an important character in the key, numerical parameters are to be emphasized and descriptive terms held secondary.

How to look for mosses and liverworts in the field

One of the joys of working with bryophytes (and lichens) in the Pacific Northwest is that most species are available year-round, in contrast to vascular plants that are dormant or disappear entirely during the dry season or in winter. You can go out in the middle of winter to sites at lower elevations and find wonderful material to work with. The only difficulties may be dealing with frozen material, or plants buried in snow. Ephemeral species mature in spring, or late summer in the case of dried-up lakebeds, but are virtually impossible to find the rest of the year.

To look for bryophytes in the field, use the same detective skills you use for vascular plants. Find out what species you could expect to occur in your area, and identify what habitats or substrates they could occupy. Next, use maps and air photos to further refine your search. A good air photo is the most useful thing you can use. It shows a great deal of habitat, and keeps you from getting lost. Topographic maps are the time-honored standard, but soil and geological maps are also very useful for certain needs. If you are lucky enough to have GIS coverage for your area, you may ask specific questions about where certain habitat elements may occur, and narrow your search to fit your needs.

When dealing with bryophytes, you must think small, think substrate, and think microclimate. Mosses and liverworts are fairly faithful to specific substrates, but there is some overlap as discussed in Part II. When looking for specific substrates, think also about different surfaces and exposures of that substrate. On a tree, check different aspects, and if the tree is leaning, check the upper and lower sides, and you will often find different species inhabiting each. On rocks and logs, check the top, sides and undersides. Don't forget to look beneath overhangs, where you might think it is too dry or too dark for bryophytes to survive. You may find the rare *Schistostega pennata*, the luminous moss staring you in the face. Moisture gradients are very important for mosses and liverworts, so check seepy rock faces as well as dry faces, where you will find different species growing. Whether collecting or just observing, always record the microhabitat, the general vegetation zone, and a few species of associated vascular plants and other bryophytes, to better characterize the habitat. Such information is extremely important for furthering our understanding of these plants, and it is often lacking from herbarium collections.

The small scale of bryophytes have their advantages and disadvantages. They are great because you don't need to worry about wilting plants and having to use a plant press. They store easily and compactly in paper packets or paper bags, and except for some liverworts, you don't need to worry about specimens drying out or getting overheated. Disadvantages include the need for a compound microscope (actually easier to obtain used than a dissecting scope), expensive books, and a steady hand and lots of patience for dissecting tiny material. However, expensive books and dissection are also needed for vascular plants! Collecting in dark places on a winter day can also be bothersome. A headlamp, flashlight, or illuminated hand lens (McCune 1994) comes in handy in these conditions.

Suggestions for conducting bryophyte inventories

Much has been written here about the lack of knowledge about bryophytes, and how this limits the ability of land managers, public and private, to make sensible, scientifically-sound decisions. It is therefore important to suggest ways in which gaps in our knowledge can be filled. This document is intended to summarize current knowledge and bring attention to vital missing information. The critical information must come from field inventories. The strategy used in designing a field inventory project will determine whether or not it is cost-effective.

Given current constraints in budget and personnel, the most efficient way to utilize limited funds and the efforts of the available qualified bryologists is to focus on small, site-directed projects. Projects should be designed so that a significant part of the budget is directed towards laboratory follow-up. Intensive microscopic analysis of fresh specimens is often necessary to identify them. In our experience, one long day in the field requires two days of laboratory and desk work.
For this reason, a project should not have more than four or five consecutive field days, followed immediately by at least six working days of laboratory and report administration. The greatest amount of information will be gained if the focus is on a site of high diversity potential, such as a spring, wetland, moist canyon, or ridge top. The area designated for intensive sampling should be less than two or three acres, or a belt transect less than one mile long. If a species of potential conservation concern is encountered, its surroundings should be reviewed to record as much as possible of its natural history.

Useful products from a field inventory project are:

1. A list of bryophyte species encountered in the project area.
2. A report or database containing at least one record for each species, indicating exact location, abundance, plant community, habitat, aspect, exposure, substrate, and reproductive status.
3. A special treatment for each species of conservation concern, such as those listed in this guide.
4. Maps and/or aerial photos detailing site locations and areas examined.
5. A report summarizing the significant bryological features of the site. Items of general interest, which might contribute to improved understanding of the regional bryoflora, should be highlighted.
6. A set of voucher specimens documenting the presence of each taxon encountered in the survey area (presuming populations of sufficient size to warrant making a collection). The curation and disposition of specimens collected during the course of field survey should be spelled out clearly in the project specifications. If herbarium-quality, labelled specimen packets are to be prepared, adequate funds should be budgeted for preparation and the archival-quality paper and other supplies needed.

PART IV. KEYS FOR THE IDENTIFICATION OF LIVERWORTS

Note: These keys have their origins in bryology classes taught in Eugene and Seattle. They work best in western Oregon and Washington. They have been revised and reformatted for this document. Future revisions are inevitable, even essential, as understanding of the liverwort flora of the Pacific Northwest grows. The author invites criticisms, of any kind, at any time, which will improve the general usefulness of the keys over a broader area.

ILLUSTRATED KEY TO THE GENERA

1a PLANTS LEAFY, the gametophytes with clearly differentiated cylindrical stems and leaves . . . . . GROUP A (Lead 3)

1b PLANTS THALLOSE, the gametophytes either flattened and strap-like or in irregular fleshy mounds

2a CELLS EACH WITH A SINGLE LARGE CHLOROPLAST; sporophytes cylindrical, growing from the base and maturing gradually from the top down, eventually splitting vertically into two twisted, thread-like valves . . . . . ANTHOCEROS

2b CELL WITH MANY CHLOROPLASTS; sporophytes with ovoid capsules, the contents maturing at one time . . . . . GROUP B (Lead 61)

GROUP A - Leafy liverworts

3a LEAVES DIVIDED 1/2 OR MORE INTO SEVERAL SLENDER LOBES OR HAIR-LIKE CILIA, the cilia mostly one cell thick (uniseriate)

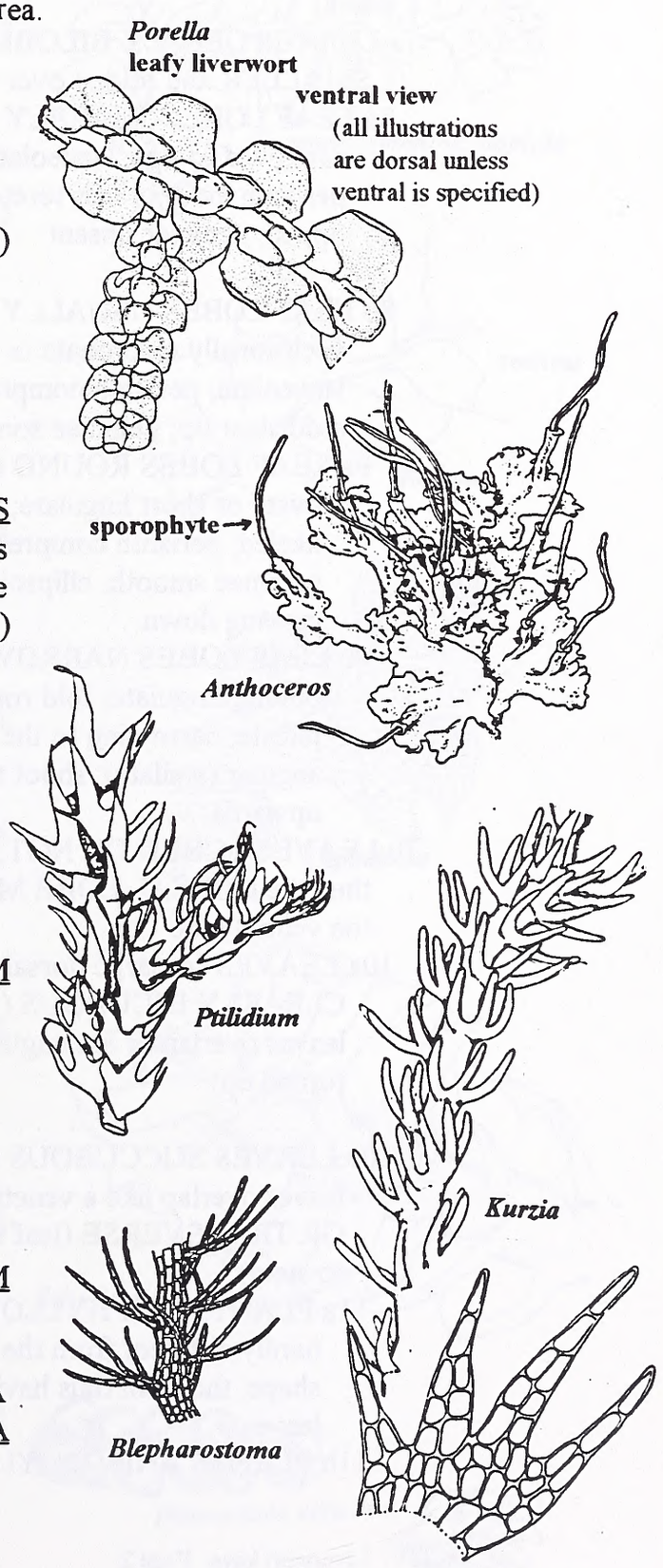
4a BASAL PORTION OF LEAVES LAMINAR, above the base divided into lobes fringed with cilia; . . . . . PTILIDIUM

4b LEAVES DIVIDED TO THE BASE INTO SEVERAL NARROW SEGMENTS, each segment mostly only 1 or 2 cells wide

5a LEAVES AND UNDERLEAVES SIMILAR, consisting of 3 or 4 segments that are uniseriate to the base; stem sparingly branched; common in cool forested areas . . . . . BLEPHAROSTOMA TRICHOPHYLLUM

5b UNDERLEAVES REDUCED TO 2 OR 3 VERY SHORT DIVISIONS; leaf segments 2 or more cells wide at base; stem regularly pinnately branched; WA and CA, maybe OR . . . . KURZIA MAKINOANA

3b LEAVES DIVIDED LESS THAN 1/2, OR, IF



DEEPLY DIVIDED, THE LEAVES BILOBED; cilia, if present at all, confined to basal part of leaf

6a OIL-BODIES ABSENT OR SOLITARY (1 per median leaf cell) in fresh, living material . . . . . GROUP A1(Lead 13)

6b OIL-BODIES 2 OR MORE PER CELL, or specimen dried

7a LEAVES DEEPLY BILOBED, DORSAL LOBE SMALLER and folded over the larger ventral lobe

8a LEAF LOBES SHARPLY POINTED, gradually narrowed to tips, lanceolate to acutely triangular; perianth more or less terete, plicate, usually white tipped; gemmae absent . . . . . DOUINA OVATA

8b LEAF LOBES USUALLY ROUNDED, occasionally mucronate or abruptly narrowed, not lanceolate; perianth compressed or terete, green or reddish at tip; gemmae sometimes present

9a LEAF LOBES ROUND OR RENIFORM to ovate or short lingulate; fold often sharp and keeled; perianth compressed, wide at the mouth; gemmae smooth, ellipsoidal; shoot tips mostly curving down . . . . . SCAPANIA

9b LEAF LOBES NARROWLY LINGULATE to oblong-lingulate; fold rounded; perianth terete, plicate, narrowing to the mouth; gemmae angular (stellate); shoot tips mostly curving upwards . . . . . DIPLOPHYLLUM

7b LEAVES LOBED OR NOT; IF bilobed and folded then the DORSAL LOBE MUCH LARGER than the ventral lobe

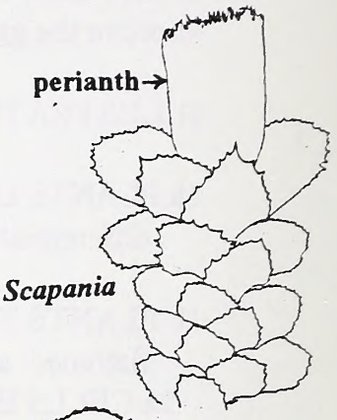
10a LEAVES (or large dorsal lobes of leaves) CLEARLY INCUBOUS (with stem tip up, the leaves overlap or are angled like a venetian blind turned up) . . . . . GROUP A2 (Lead 20)

10b LEAVES SUCCUBOUS (with stem tip up, the leaves overlap like a venetian blind turned down) OR TRANSVERSE (leaf inserted at right angles to stem)

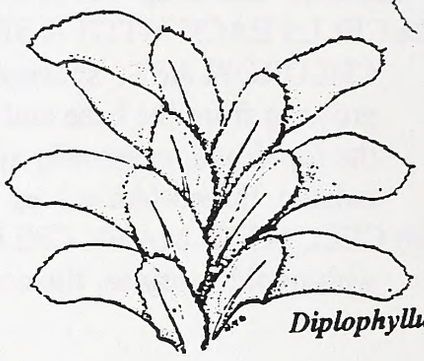
11a PLANTS ISOPHYLLOUS, the underleaves hardly different from the leaves in size and shape, the stem thus having 3 equal rows of leaves . . . . . GROUP A3 (Lead 25)

11b PLANTS ANISOPHYLLOUS; the underleaves

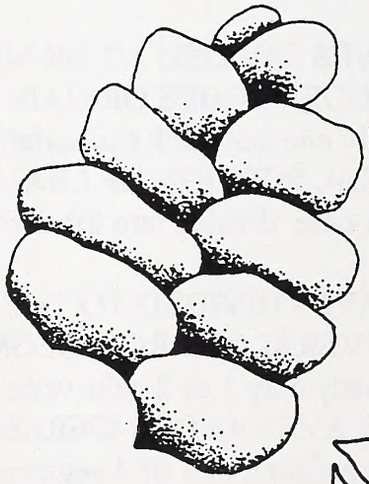
Douinia



Scapania

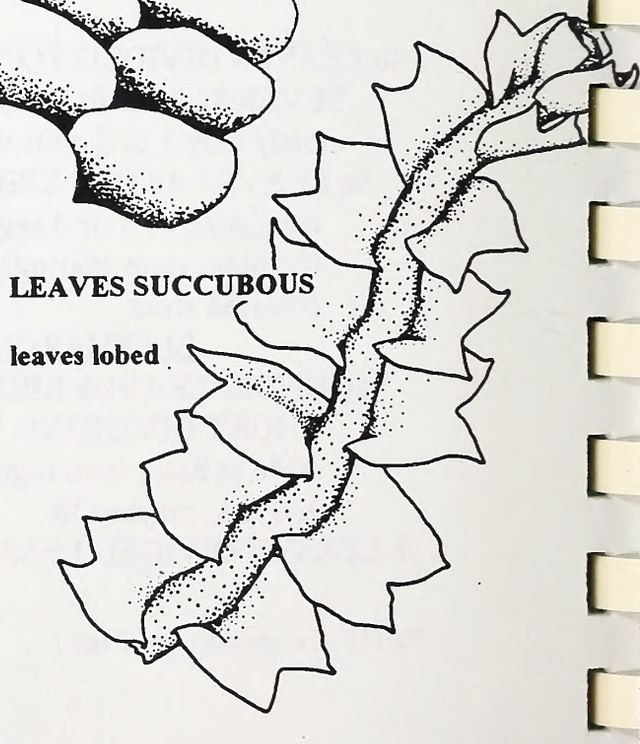


Diplophyllum



LEAVES INCUBOUS

leaves round



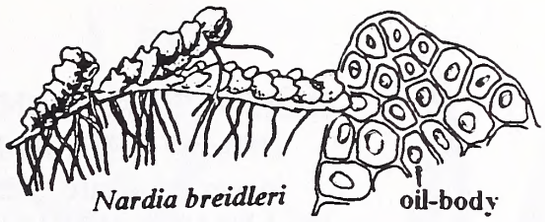
LEAVES SUCCUBOUS

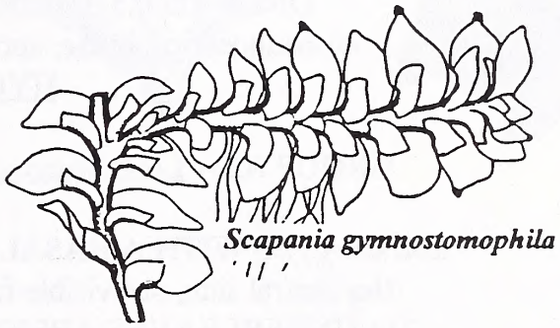
leaves lobed

smaller than and/or differing from the leaves, or underleaves absent

12a LEAVES ROUND TO OVATE, some species with occasional leaves retuse or emarginate, some with wavy or minutely dentate margins . . . . . GROUP A4 (Lead 28)

12b LEAVES REGULARLY LOBED (leaf tip notched); the sinus (notch) between the lobes shallow to deep; the leaf lobes round to pointed, equal to quite unequal . . . . . GROUP A5 (Lead 37)





GROUP A1 -- Leafy liverworts with oil-bodies solitary or lacking

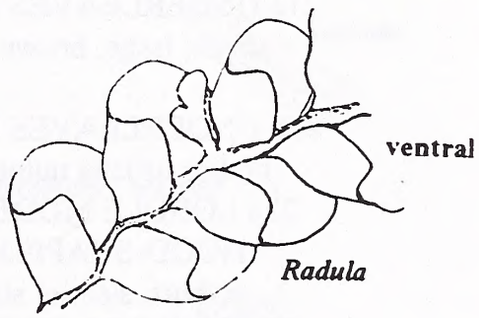
13a OIL-BODIES PRESENT, 1 PER CELL (rarely more)

14a OIL-BODIES COLORLESS, lumpy-amorphous; minute alpine plants growing on soil . . . . . NARDIA BREIDLERI

14b OIL-BODIES BROWN OR GREENISH-BROWN, plate-like and granular; growing on rocks or trees

15a LEAVES BILOBED, THE DORSAL LOBE MUCH SMALLER than the ventral lobe; very rare . . . . . SCAPANIA GYMNOSTOMOPHILA

15b LEAVES BILOBED, THE DORSAL LOBE MUCH LARGER than the ventral lobe; widespread in western Oregon . . . . . RADULA

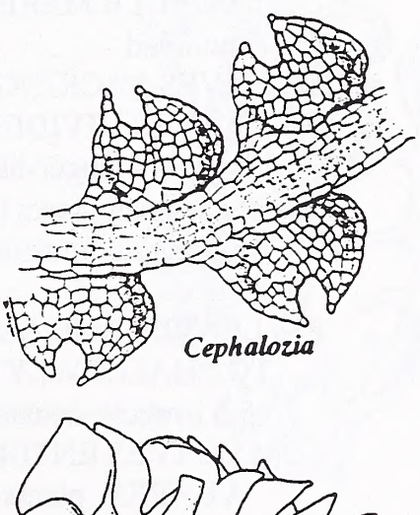


13b OIL-BODIES LACKING IN ALL CELLS

16a UNDERLEAVES SMALL OR LACKING

17a PLANTS SMALL, to 1.2 mm wide; stems slender, to 0.35 mm thick; no underleaves; many species; widespread . . . . . CEPHALOZIA

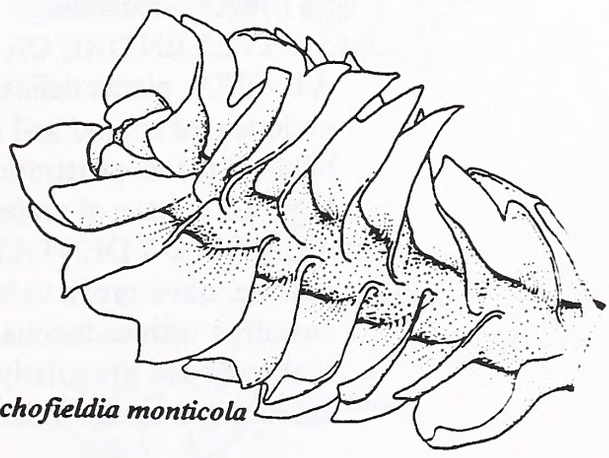
17b PLANTS MEDIUM SIZED, 1.5 - 3 mm wide; stems stout and fleshy, to 0.9 mm thick; with small underleaves; rare, in subalpine meadows or under heather . . . . . SCHOFIELDIA MONTICOLA

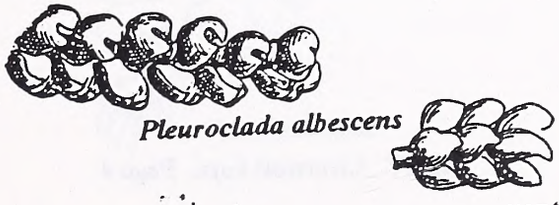


16b UNDERLEAVES LARGE, mostly as long as the leaves

18a UNDERLEAVES LANCEOLATE, unlike the bilobed leaves; very rare, to be expected in bogs . . . . . PLEUROCLADA ALBESCENS

18b UNDERLEAVES BILOBED, much like the bilobed leaves





19a LEAVES AND UNDERLEAVES BIFID TO BELOW THE MIDDLE, the lobes acuminate; leaves imbricate; stems julaceous . . . ANTHELIA

19b LEAVES AND UNDERLEAVES BILOBED ONLY TO 0.5 THEIR LENGTH, the lobes rounded to obtuse, spreading . . . . . HYGROBIELLA LAXIFLORA

Anthelia

Hygrobiella laxiflora

GROUP A2 -- Leafy liverworts with incubous leaves

20a LEAVES WITH A BASAL LOBULE folded under on the ventral side, not visible from above

21a UNDERLEAVES ABSENT; the cells each with a single, large, brown or greenish-brown oil-body . . . . . RADULA

21b UNDERLEAVES PRESENT and conspicuous; oil-bodies usually numerous in each cell

22a LOBULE MODIFIED INTO AN URN- OR HOOD-SHAPED structure attached to the stem by a short, slender stalk . . . . . FULLANIA

22b LOBULE MERELY A LEAFY FLAP, not greatly modified . . . . . PORELLA

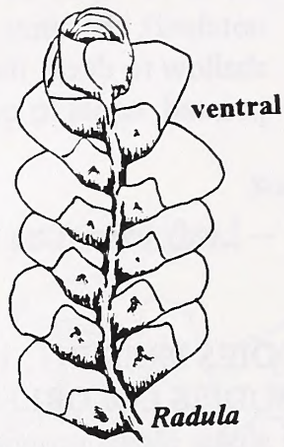
20b LEAVES LACKING A LOBULE

23a LEAVES DIVIDED 1/3 TO 1/2 THEIR LENGTH into 3 or 4 finger-like lobes; underleaves deeply 3-4 lobed; small plants (the shoots less than 1 mm across) with regular pinnate branching . . . . . LEPIDOZIA REPTANS

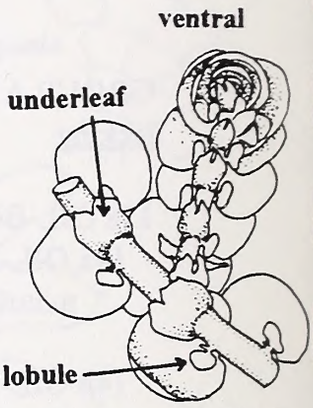
23b LEAVES AND (usually) UNDERLEAVES ENTIRE TO SHALLOWLY 2-3 TOOTHED; larger plants with irregular branching

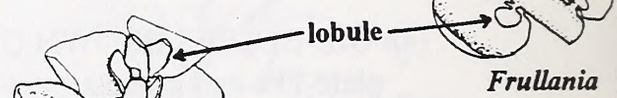
24a LEAVES ENTIRE OR RARELY BIDENTATE AT APEX; plants delicate, pale, often with gemmae; underleaves rotund and emarginate to deeply bilobed; plants prostrate with numerous rhizoids bunched at base of underleaves . . CALYPOGEIA

24b LEAVES 2-3 DENTATE AT APEX; plants firm, opaque, olive-green to brownish; lacking gemmae but often with caducous leaves; underleave squarish, shallowly and irregularly 2-3 dentate; plants mostly ascending with few rhizoids . . . . . BAZZANIA

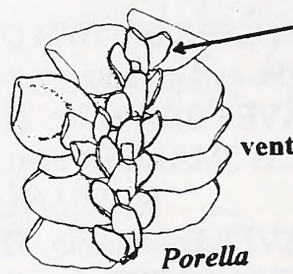


Radula

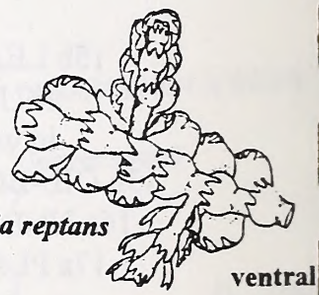




Frullania

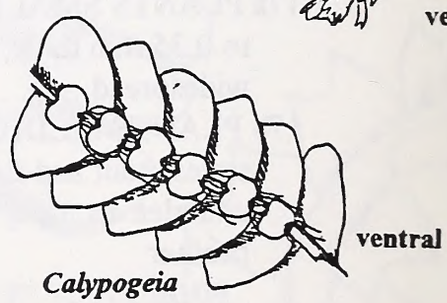


Porella

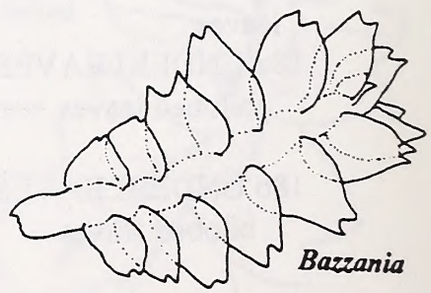


Lepidozia reptans

ventral



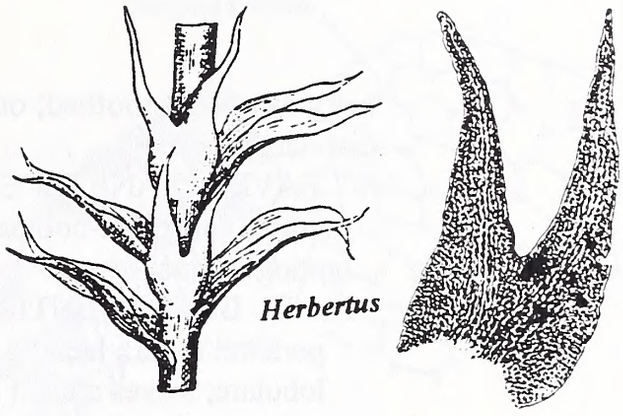
Calypogeia



Bazzania

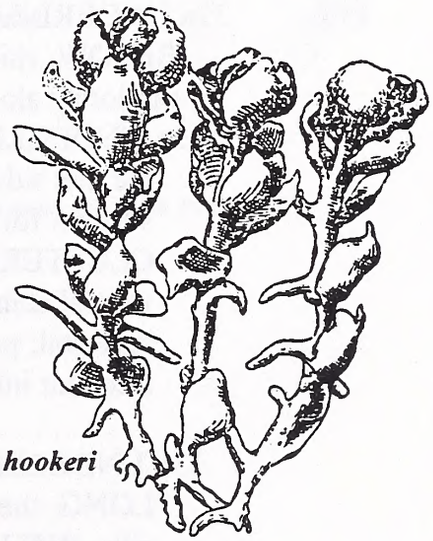
GROUP A3 -- Leafy liverworts with isophyllous shoots
(note: few found at low elevation)

25a LEAVES AND UNDERLEAVES BIFID TO BELOW THE MIDDLE, the lobes acuminate; leaves mostly imbricate
26a LEAVES WITH BANDS OF ELONGATED CELLS extending up the lobes; leaf cells with coarse, bulging trigones; oil bodies averaging 7-13 per cell; plants dark brown or blackish; leaf tips not appressed; rare, on rocks or trees . . . . . HERBERTUS
26b LEAF CELLS MORE OR LESS UNIFORM IN SHAPE and wall thickness, without bulging trigones; no oil-bodies; leaves tightly appressed, the shoots julaceous; plants usually whitish; frequent in alpine-subalpine terrestrial habitats . . . . . ANTHELIA
25b LEAVES AND UNDERLEAVES ENTIRE TO BILOBED, when bilobed the sinus hardly reaching the middle of the leaf and the lobes rounded to obtuse; leaves usually remote, hardly overlapping, spreading
27a LEAVES BILOBED 0.5 TO 0.25 THEIR LENGTH; oil-bodies rare or absent; perianths long; rare . . . . . HYGROBIELLA LAXIFLORA
27b LEAVES ENTIRE, irregularly ovate to rhombic; oil-bodies conspicuous, smaller than chloroplasts, numerous; perianths absent, the sporophyte emerging from a large, fleshy calyptra; rare . . . . . HAPLOMITRIUM HOOKERI


Herbertus

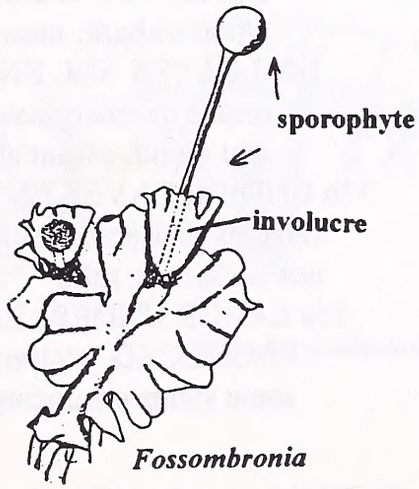

Anthelia

***Hygrobiella* - see lead 19b**


Haplomitrium hookeri

GROUP A4 -- Leafy liverworts with round, succubous leaves

28a UNDERLEAVES ABSENT OR MINUTE, often reduced to tiny, few-celled projections
29a STEMS STOUT, FLESHY; leaves irregularly shaped with wavy, ruffled margins; rhizoids (but not stems) intensely purplish-red; sex organs on upper side of stem . . . . . FOSSOMBRONIA
29b STEMS RELATIVELY SLENDER, FIRM; leaves clearly rotund or ovate; rhizoids not reddish unless stems or basal parts of leaves similarly colored; antheridia axillary; archgonia terminal on stem
30a LEAVES WITH DORSAL MARGINS RECURVED and with a shallow but distinct trough extending up the leaf midline from the base; leaf



Fossombronia

margins usually toothed; oil-bodies composed of distinct globules . . . . . PLAGIOCHILA

30b LEAVES PLANE OR EVENLY CONCAVE; leaf margins entire; oil-bodies finely granulose to almost homogeneous

31a ALL BRACTS ENTIRE; bracteole absent; perianth mouth lacking cilia although sometimes lobulate; leaves almost never retuse; usually on soil, occasionally aquatic or on organic substrates; widespread . . . . . JUNGERMANNIA

31b BASED OF FEMALE BRACTS LACERATE; bracteole present; perianth mouth ciliate; a few leaves retuse, not common but appearing regularly; underleaves present but usually minute; on decaying bark or wood; mainly restricted to east side of the Cascades . . . . . JAMESONIELLA AUTUMNALIS

28b UNDERLEAVES RELATIVELY LARGE AND CONSPICUOUS, at least at tips of sterile shoots

32a UNDERLEAVES BIFID TO THE MIDDLE OR BELOW; rhizoids in discrete patches, not scattered randomly along lower side of stem

33a UNDERLEAVES LONGER THAN WIDE, with parallel sides, the two acuminate lobes pointing straight forward; RHIZOIDS DENSELY CLUSTERED AROUND RAISED RED PADS on ventral stem surface between the underleaves; on bare soil; particularly abundant near coast though frequent inland . . . . . GYROTHYRA UNDERWOODIANA

33b UNDERLEAVES MOSTLY WIDER THAN LONG, the lobes divergent or with lateral lobes or cilia; RHIZOIDS IN TUFTS at base of underleaves

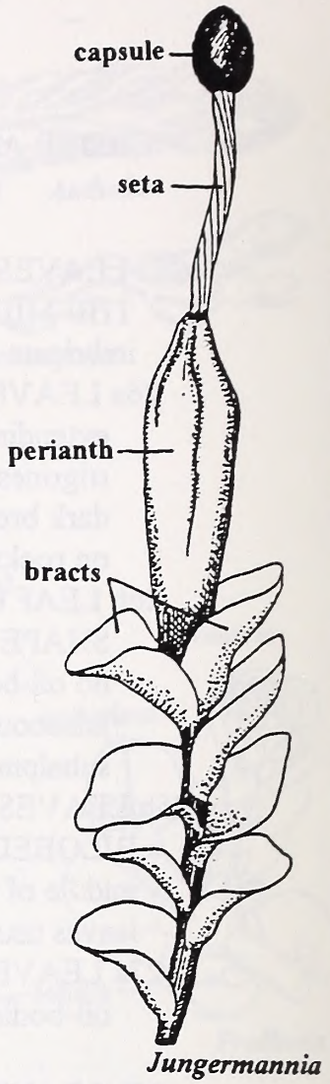
34a AT LEAST SOME LEAVES ON THE STEM DISTICTLY BILOBED; most often on decaying wood or bark, mesophytic . . . . LOPHOCOLEA

34b LEAVES ALL ENTIRE except for occasional retuse or emarginate apices; on soil, rock or rarely wet wood, essentially aquatic CHILOSCYPHUS

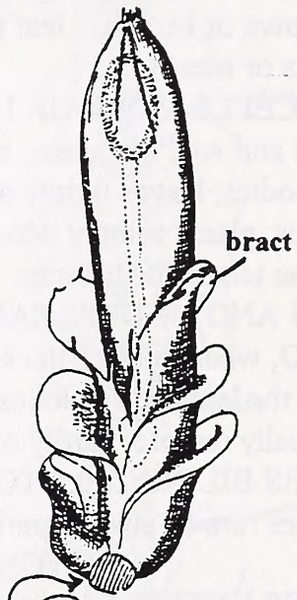
32b UNDERLEAVES ENTIRE, LANCEOLATE; rhizoids scattered along lower side of stem, or sparse, not in discrete tufts

35a LARGE UNDERLEAVES SPORADICALLY PRODUCED, scattered along the shoot and with some stems producing minute underleaves only;

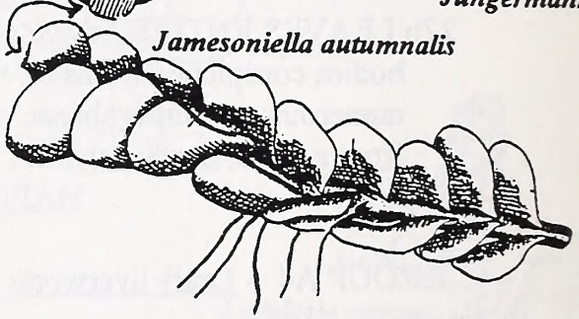
Plagiochila

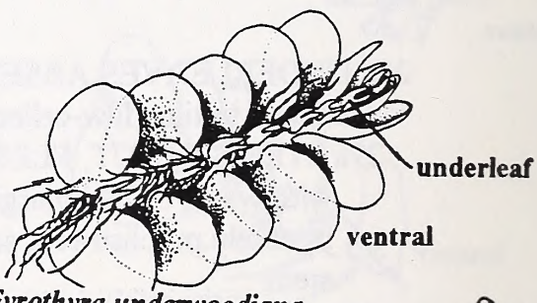


Jungermannia



Jamesoniella autumnalis





Gyrothyra underwoodiana

Lophocolea ventral

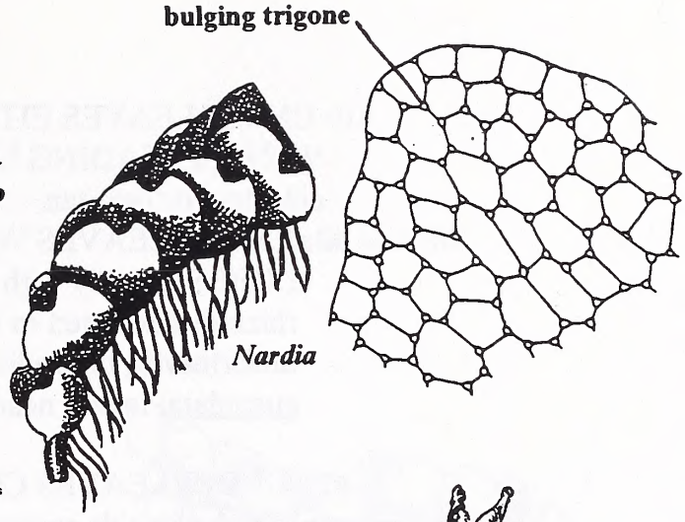
Chiloscyphus

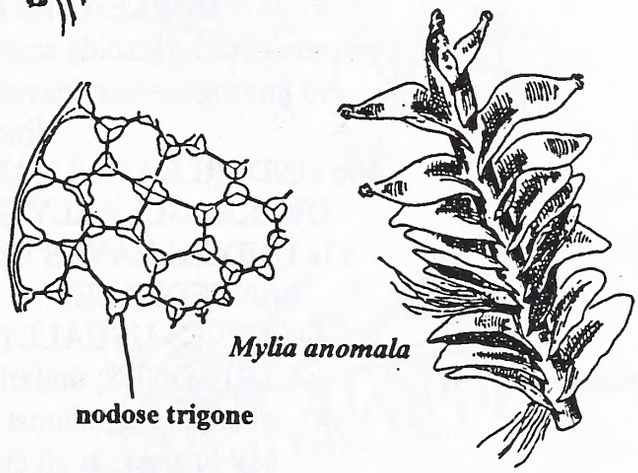
known only from Waldo Lake
. . . . . JAMESONIELLA AUTUMNALIS var. HETEROSTIPA *Jamesoniella* **see lead 31b**

35b UNDERLEAVES REGULARLY PRODUCED, widely distributed

36a TRIGONES OFTEN BULGING BUT NEVER COARSELY NODOSE; median cells small to medium sized (15-40 µm); oil-bodies homogeneous or granular; gemmae absent;on soil . . . . . NARDIA

36b TRIGONES COARSELY NODOSE, CELL WALLS ALSO WITH KNOT-LIKE THICKENINGS; cells large (45-50 micrometers wide or more); oil-bodies botryoidal; gemmae frequent; on Sphagnum . . MYLIA ANOMALA





GROUP A5 --Leafy liverworts with lobed leaves

37a RHIZOIDS BRIGHT PURPLISH-RED; stem and leaves pure green; leaves mostly quadrate, with wavy or rufled margins, appearing irregularly lobed . . . . . FOSSOMBRONIA

37b RHIZOIDS USUALLY COLORLESS OR BROWNISH, occasionally red when stems and/or leaves are similarly pigmented; rhizoids sometimes scarce; leaves distinctly and regularly lobed

38a PLANTS MINUTETO VERY SMALL, healthy shoots less than 1 mm wide (excluding stray, depauperate strands); leaves bilobed or notched . . . . . GROUP A6 (Lead 47)

38b PLANTS SMALL TO LARGE, normal shoots mostly much more than 1 mm wide; leaves bilobed or not

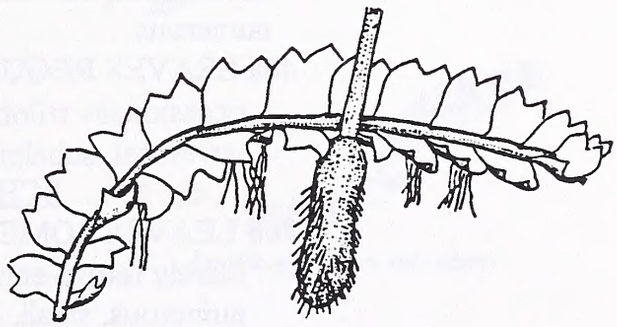
39a UNDERLEAVES LACKING OR INCONSPICUOUS ON STERILE SHOOTS . . . . . GROUP A7 (Lead 55)

39b UNDERLEAVES QUITE DISTINCT ON STERILE SHOOTS

40a UNDERLEAVES REGULARLY BIFID TO BIFID-CILIATE

41a UNDERLEAVES SIMPLY BIFID TO BELOW THE MIDDLE, the lobes straight, entire, acuminate, pointing forward; oil-bodies brown, opaque . . . . . GEOCALYX GRAVEOLENS

Fossombronia **see lead 29a**



Geocalyx graveolens

41b UNDERLEAVES EITHER CILIATE OR WITH SPREADING LOBES, oil-bodies colorless or pale tan

42a UNDERLEAVES WITH SPREADING LOBES, usually with straight lateral teeth; rhizoids restricted to small area at base of underleaves; oil-bodies botryoidal except in L. cuspidata; leaves nearly horizontal . . . . . LOPHOCOLEA

42b UNDERLEAVES CILIATE, the cilia contorted; rhizoids scattered; oil-bodies granulose to homogeneous; leaves oblique LOPHOZIA (includes BARBILOPHOZIA)

40b UNDERLEAVES NARROW, LANCEOLATE OR IRREGULARLY SHAPED

43a UNDERLEAVES UNIFORMLY LANCEOLATE

44a CELLS USUALLY WITH BULGING TRIGONES; underleaves quite entire; leaves overlapping, almost transversely inserted; on soil or peat, at all elevations . . . . . NARDIA

44b CELL WALLS THIN, TRIGONES HARDLY DEVELOPED; underleaves often toothed on side; leaves spreading, nearly horizontally inserted; on peat at high elevations . . . . . HARPANTHUS FLOTOVIANUS

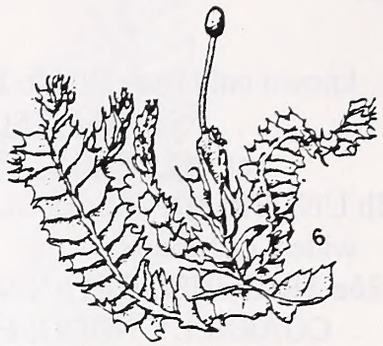
43b UNDERLEAVES SMALL AND SUBULATE OR FLAP-LIKE and varying to rounded-lobed

45a UNDERLEAVES SMALL, SUBULATE; oil-bodies large, at least twice the size of the chloroplasts, granulose . . . . . LOPHOZIA

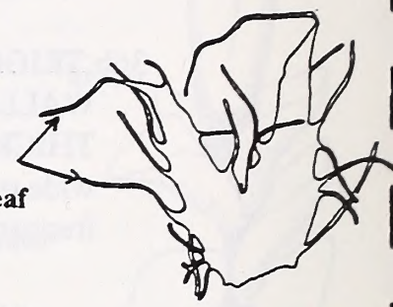
45b UNDERLEAVES VARIABLE, from small flaps to rather large and round-lobed on the same shoot; oil-bodies absent or small and numerous

46a LEAVES REGULARLY BILOBED, occasionally trilobed; oil-bodies absent; rare, terrestrial, subalpine to alpine . . . . . SCHOFIELDIA MONTICOLA

46b LEAVES SOMETIMES UNLOBED or merely retuse-emarginate; oil-bodies numerous, small, granulose or homogeneous; rare, aquatic, on rocks in small streams . . . . CHILOSCYPHUS GEMMIPARUS

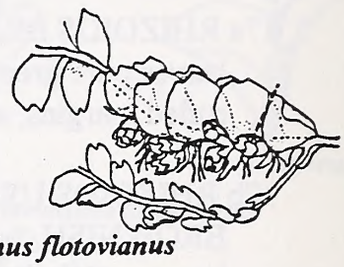


Lophocolea

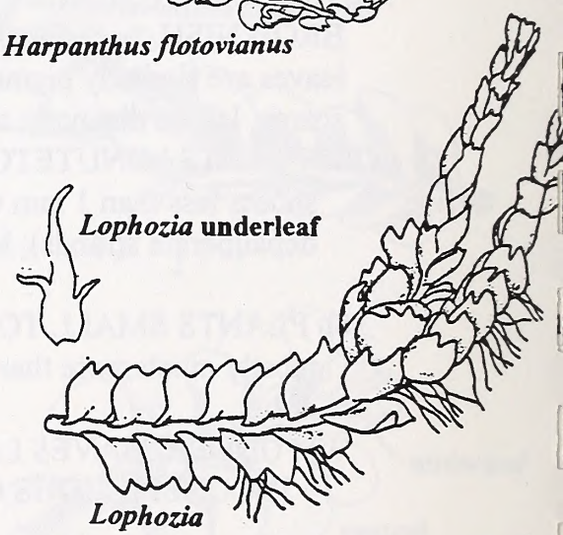


cilia of *Lophozia* underleaf

***Nardia* see lead 36a**



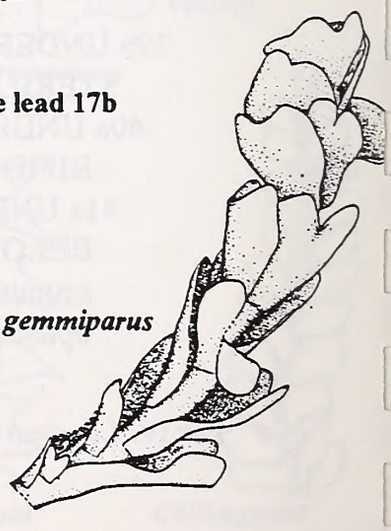
Harpanthus flotovianus



***Lophozia* underleaf**

Lophozia

***Schofieldia* see lead 17b**



Chiloscyphus gemmiparus

GROUP A6 -- Tiny leafy liverworts with bilobed leaves

Note: this key is intended for use with plants whose average size is less than 0.5 mm in diamater and maximum size very small, i.e., shoots less than one millimeter across. Most leafy liverworts can produce juvenile or depauperate strands in this size range; such should be excluded before using this key.

47a UNDERLEAVES CONSPICUOUS ON STERILE SHOOTS

48a UNDERLEAVES ALMOST OR QUITE AS LONG AS THE LEAVES . . . . . PLEUROCLADA ALBESCENS

48b UNDERLEAVES LESS THAN HALF AS LONG AS THE LEAVES

49a OIL-BODIES SOLITARY OR 2-5 PER CELL, very large, homogeneous . . . . . NARDIA

49b OIL-BODIES SEVERAL PER CELL, about as small or smaller than the chloroplasts, granulose . . . . . CEPHALOZIELLA

47b UNDERLEAVES MINUTE OR ABSENT ON STERILE SHOOTS

50a STERILE SHOOTS JULACEOUS, the leaves appressed and overlapping; perianth poorly developed, never projecting far beyond the female bracts; oil-bodies few, 2-3 (rarely to 6) per cell, lumpy-amorphous to granulose, more than twice as large as the chloroplasts

51a PLANTS PALE GREEN OR WHITISH . . . . . GYMNOMITRION

51b PLANTS DARK GREEN TO BROWN OR EVEN BLACKISH . . . . . MARSUPELLA

50b STERILE SHOOTS WITH LEAVES MORE-OR-LESS REMOTE and/or spreading; perianth well developed; oil-bodies various, usually more than 4/cell but sometimes lacking

52a LEAVES TRANSVERSELY INSERTED

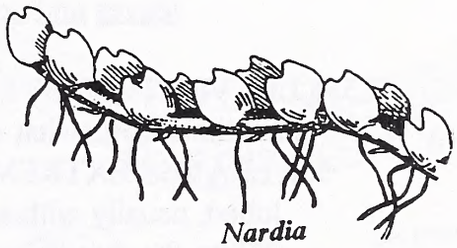
53a SHOOTS 0.5 mm WIDE OR WIDER; oil- bodies distinctly botryoidal . . . . . ANASTROPHYLLUM MINUTUM

53b SHOOTS LESS THAN 0.5 mm WIDE; oil-bodies granulose . . . . . CEPHALOZIELLA

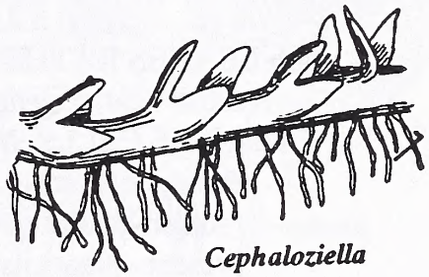
52b LEAVES DISTINCTLY SUCCUBOUS

54a PLANTS PELLUCID, THE CELLS LACKING OIL- BODIES; perianths trigonous; cells without

Pleuroclada see lead 18a



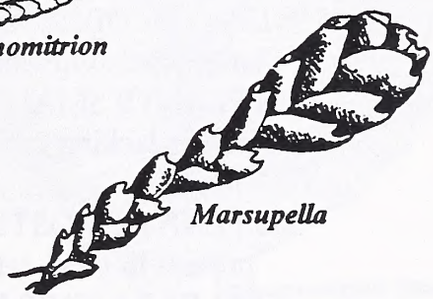
Nardia



rhizoids

Cephaloziella

Gymnomitrion



Marsupella

Anastrophyllum minutum

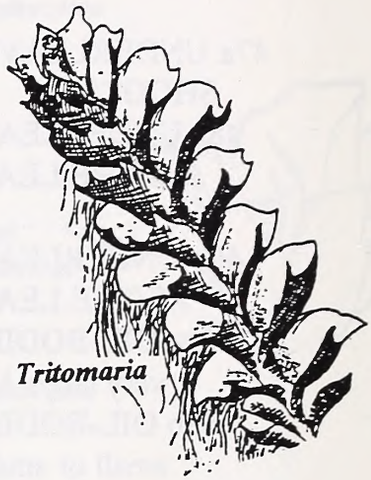
trigones . . . . . CEPHALOZIA

54b PLANTS OPAQUE, THE CELLS WITH OIL-BODIES; perianths cylindrical; cells usually with trigones . . . . . LOPHOZIA

Cephalozia **see lead 17a**

Lophozia **see lead 45a**

GROUP A7 -- Small to large leafy liverworts with lobed leaves and no obvious underleaves



Tritomaria

55a LEAVES TRANSVERSELY INSERTED (the leaves sometimes somewhat secund); plants typically erect

56a LEAVES EXTREMELY ASYMMETRICAL, 2-3-lobed, usually with a slender, divergent dorsal lobe 2/3 up the margin; usually with masses of reddish-brown gemmae at shoot apex . . . . . TRITOMARIA

56b LEAVES RATHER EVENLY BILOBED; with reddish-scarlet gemmae or gemmae absent

57a LEAF CELLS WITHOUT TRIGONES, cell walls evenly thickened; oil-bodies distinctly botryoidal; reddish-scarlet gemmae frequent; perianths (when present--plants usually sterile) long emergent; alpine . . . . . ANASTROPHYLLUM MINUTUM

57b LEAF CELLS WITH DISTINCT TRIGONES, usually bulging; oil-bodies finely granulose or lumpy-amorphous; gemmae absent; perianth short or absent; widespread . . . . . MARSUPELLA

55b LEAVES OBLIQUELY INSERTED, SUCCUBOUS; plants often sprawling or decumbent

58a PLANTS SMALL (< 1.2 mm wide), PELLUCID; oil-bodies lacking in all cells; perianths trigonous . . . . . CEPHALOZIA

58b PLANTS MOSTLY LARGER, OPAQUE; oil-bodies present in most cells; perianths cylindrical

59a LEAF LOBES ROUNDED; oil-bodies 4-8 per cell, granulose; perianths inflated, caducus; plants usually dark brown or or blackish; gemmae absent; montane . . . . . GYMNOCOLEA INFLATA

59b LEAF LOBES ACUTE OR IF ROUNDED WITH NUMEROUS (>12) OIL-BODIES; perianths neither inflated nor caducous

60a TERRESTRIAL, on various substrates; plants usually greenish to light brown or reddish; oil-bodies various; gemmae often present, 1-2 celled; widespread . . . LOPHOZIA/BARBILOPHOZIA

Anastrophyllum **see lead 53a**

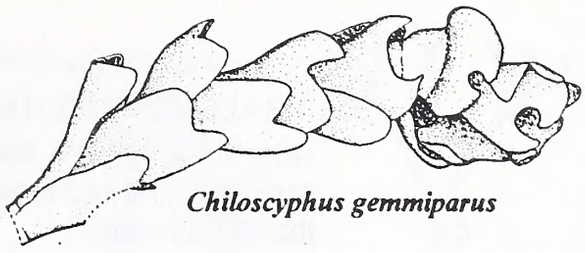
Marsupella **see lead 51b**

Cephalozia **see lead 17a**

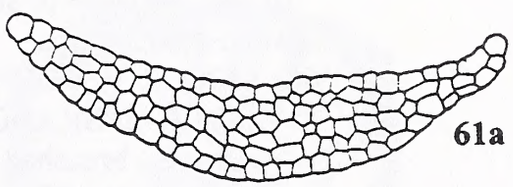
Gymnocolea inflata

Lophozia **subgen.** *Barbilophozia*

60b AQUATIC, attached to stones in running water; dark green to blackish; oil-bodies homogeneous to finely granulose; fasciculate, multi-cellular gemmae present on upper leaf margins; (usually with sporadic large underleaves); rare, alpine
. . . . . CHILOSCYPHUS GEMMIPARUS

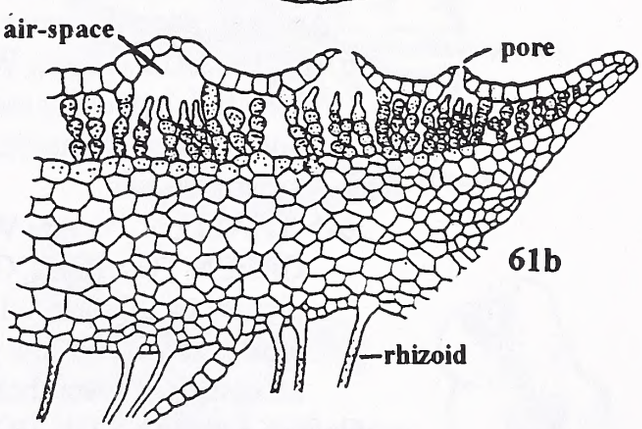

Chiloscyphus gemmiparus

GROUP B --Thallose liverworts



61a THALLUS TISSUE HOMOGENEOUS; composed solely of thin-walled, translucent cells, lacking air chambers; rhizoids all with smooth internal walls; lacking ventral scales (except Blasia)
. . . . . GROUP B1 (Lead 62)

61b THALLUS TISSUE HETEROGENEOUS, composed of different cell types, usually with a distinct epidermis and internal air chambers; rhizoids dimorphic, smooth-walled ones mingled with those having internal peg-like thickenings; almost always with ventral scales
. . . . . GROUP B2 (Lead 69)



GROUP B1 -- Thallose liverworts with solid, undifferentiated tissue

62a THALLUS IN SMALL MOUNDS OR ROSETTES; capsules sessile or embedded in thallus

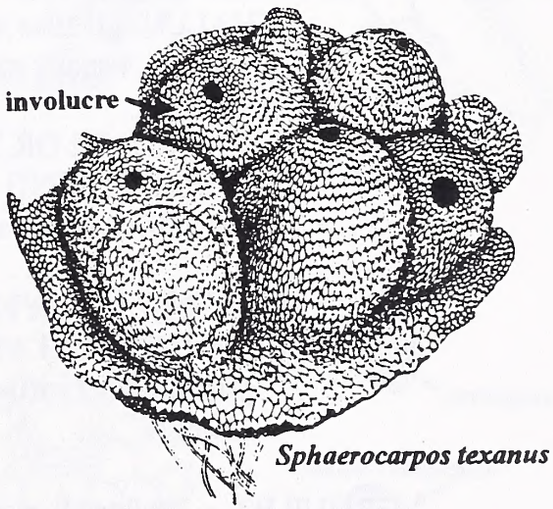
63a FLASK-SHAPED INVOLUCRES CONSPICUOUS, individually sheathing antheridia or archegonia (plants dioecious), sessile, crowded on the upper surface of thallus; mostly weedy on bare soil
. . . . . SPHAEROCARPOS

63b ARCHEGONIA, ANTHERIDIA, AND CAPSULES EMBEDDED in the thallus
. . . . . miskeyed RICCIA (see B1, Lead 69))

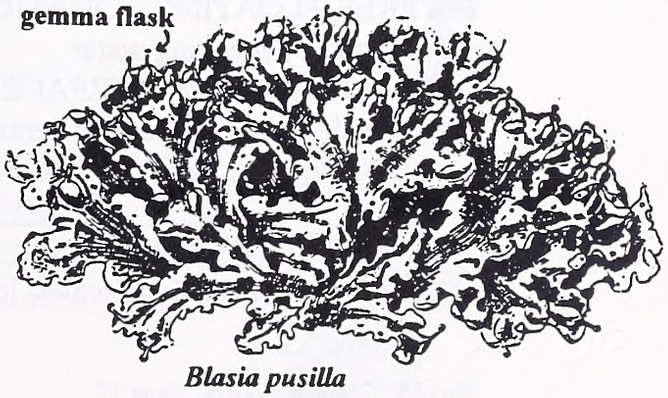
62b THALLUS RIBBON-LIKE, often regularly and much branched; capsules exserted on a long seta

64a VENTRAL SCALES PRESENT, small, in two rows; thallus producing multicellular gemmae of two kinds: stellate gemmae exogenously on dorsal surface and ovoid gemmae in flask-shaped containers; Nostoc colonies embedded in thallus, visible with hand lens
. . . . . BLASIA PUSILLA

64b VENTRAL SCALES ABSENT; gemmae (if any) not stellate, not produced in containers; Nostoc absent



Sphaerocarpos texanus



Blasia pusilla

65a THALLUS WITH HAIRS ON MARGIN (one species hairy above, also); thallus with distinct, narrow midrib and broad, unistratose wings; less than 2 mm wide
. . . . . METZGERIA

65b THALLUS WITHOUT HAIRS; thallus thinning gradually from middle to margin, unistratose portion (if any) not wide or abruptly demarcated; often wider than 2 mm

66a SEX ORGANS ON SHORT VENTRAL OR LATERAL BRANCHES; thallus pinnately or palmately branched, less than 3 mm wide (except Aneura); rhizoids sparse

67a THALLUS 3-8 mm WIDE, GLOSSY DARK GREEN; branching more or less pinnate; oil-bodies small, numerous, 10-30 per cell; plants prostrate . . . . . ANEURA PINGUIS

67b THALLUS 1-2 mm WIDE, DULL OLIVE GREEN TO LIGHT GREEN; branching pinnate or palmate; oil-bodies absent or large, mostly solitary or few per cell; plants often with ascending or erect thalli . . . . . RICCARDIA

66b SEX ORGANS ON DORSAL SURFACE OF THALLUS; thallus more or less dichotomously branching, usually more than 5 mm wide; rhizoids numerous

68a LACERATE OR TOOTHED SCALES SURROUNDING ANTHERIDIA AND ARCHEGONIA; alpine only, where common
. . . . . MOERCKIA BLYTTII

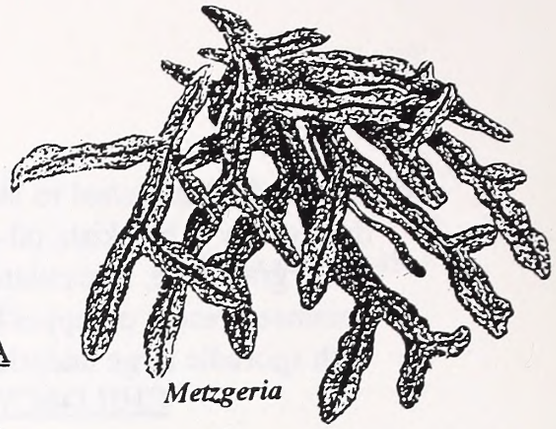
68b TUBULAR OR FLAP-LIKE INVOLUCRES PROTECTING ARCHEGONIA; antheridia in pits in dorsal surface, widespread (including alpine) . . . . . PELLIA

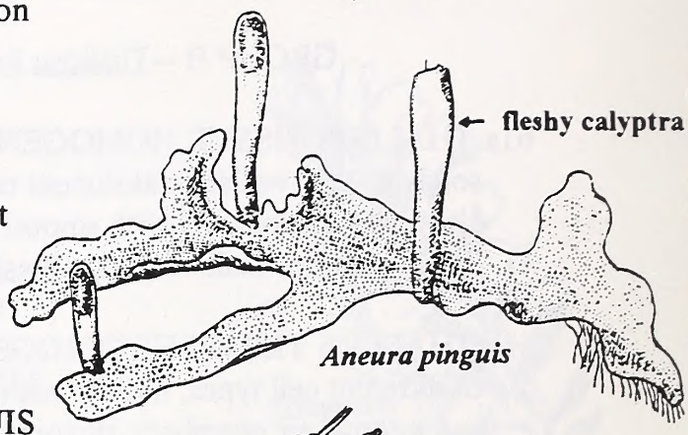
GROUP B2 -- Thallose liverworts with differentiated tissue

69a FREE-FLOATING AQUATICS, sometimes stranded on mud by receding water

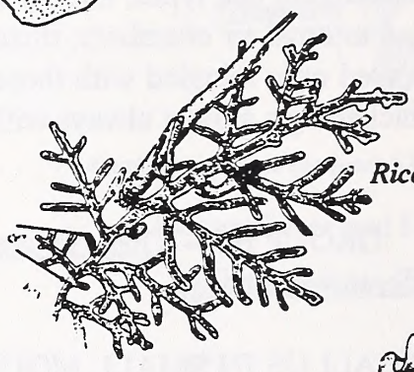
70a FLOATING ON SURFACE OF WATER; with long, pendent, purplish scales ventrally; lobes dark green, 4-10 mm wide, with few bifurcations
. . . . . RICCIOCARPOS NATANS

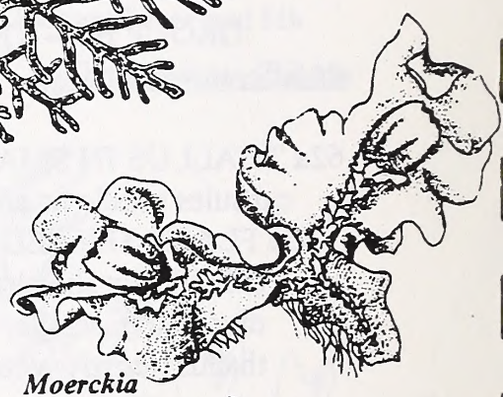
70b FLOATING BENEATH SURFACE OF WATER; lacking conspicuous scales; lobes light green, narrow,

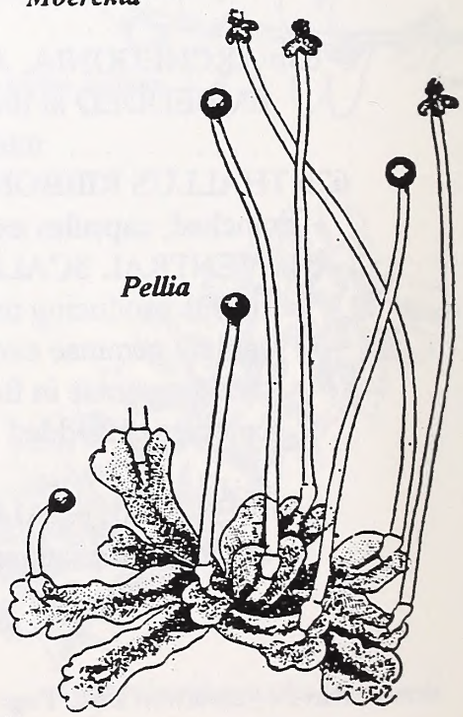

Metzgeria



Aneura pinguis


Riccardia


Moerckia


Pellia

Ricciocarpos see next page

to 1.5 mm wide, repeatedly bifurcating . . . . . RICCIA FLUITANS

69b TERRESTRIAL PLANTS growing attached to the substrate

71a PLANTS REPEATEDLY BIFURCATING, FORMING ROSETTES; lobes with sharp, dorsal, median furrow, at least at lobe tip; sex organs embedded in thallus, the capsule also remaining embedded; lacking elaters . . . . . RICCIA

71b PLANTS NOT FORMING CLEAR ROSETTES but sprawling with irregular branching; lobes sometimes canaliculate but not sharply furrowed; sex organs variously placed, the archegonia and capsules usually developing in structures elevated above surface of thallus; elaters present

72a GEMMAE CUPS PRESENT ON DORSAL SURFACE OF THALLUS

73a GEMMAE CUPS CIRCULAR; male and female sex organs both on stalked receptacles (on separate plants); common near streams in all parts of the state . . . . . MARCHANTIA

73b GEMMAE CUPS CRESCENTIC (lunate, open on one side); the reproductive structures not known in our area; introduced and mainly weedy in urban areas but becoming established along coastal roads . . . . . LUNULARIA CRUCIATA

72b GEMMAE CUPS, GEMMAE ABSENT

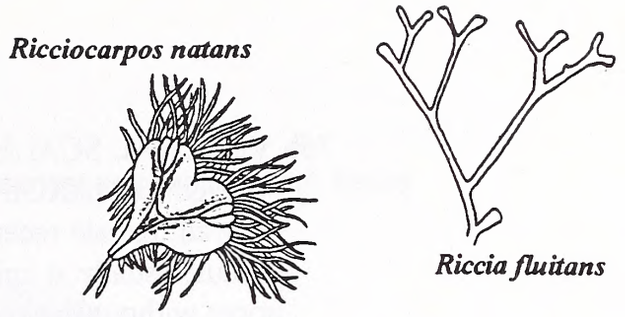
74a CELLS OF UPPER EPIDERMIS WITH LARGE, OFTEN BULGING, TRIGONES

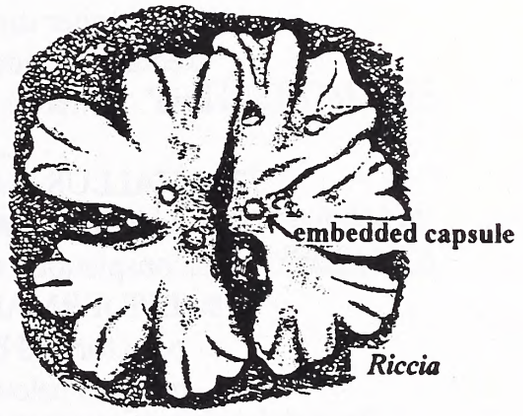
75a STALKED RECEPTACLES LACKING, the capsules maturing on underside of thallus tips, inside a 2-valved, black, shiny involucre; common . . . . . TARGIONIA HYPOPHYLLA

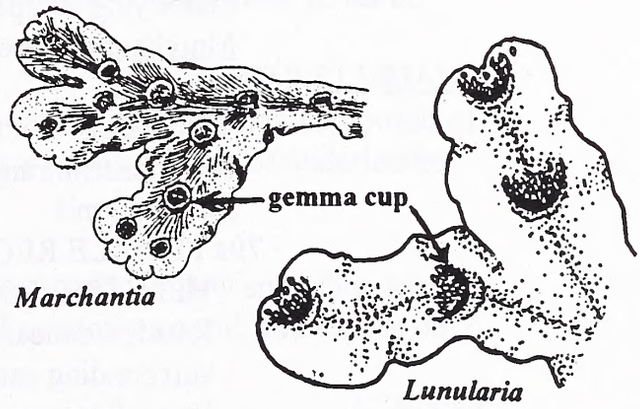
75b CAPSULES BORNE ON STALKED, STAR-SHAPED RECEPTACLES; to date only known from Columbia River Gorge and Wallowas . . . . . REBOULIA HEMISPHAERICA

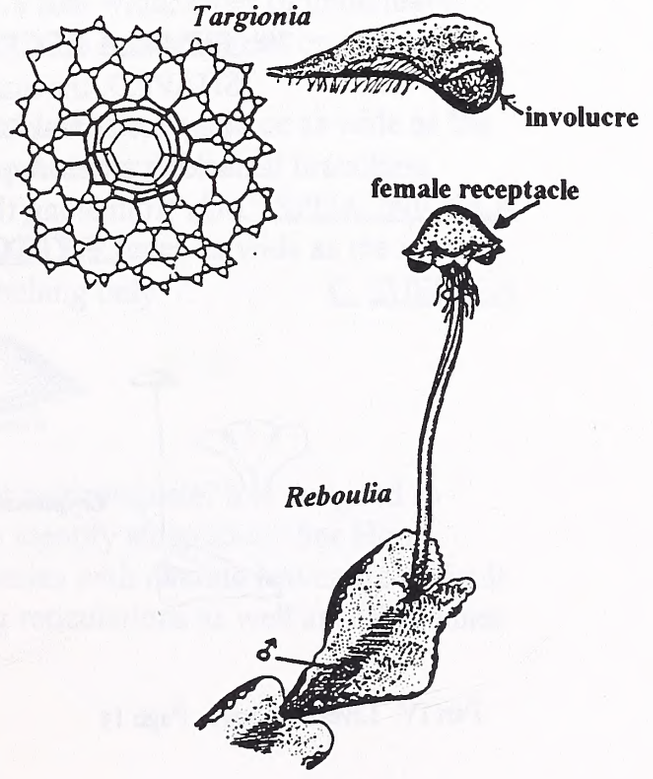
74b CELLS OF UPPER EPIDERMIS WITHOUT LARGE TRIGONES

76a PALE VENTRAL SCALES PROTRUDING CONSPICUOUSLY BEYOND THALLUS MARGINS; female receptacles arising from mid dorsal surface of thallus (unique in this regard among all thallose liverworts in the state); cells around pores with thickened radial walls









. . . . . ATHALAMIA HYALINA

76b VENTRAL SCALES NOT CONSPICUOUS AROUND MARGINS, or, if evident then dark colored; female receptacles arising from edge of thallus, usually at apical notch; cells around pores without thickened radial walls

77a THALLUS LARGE, 8-20 mm (or more) wide; upper surface with coarse, polygonal areolation evident at arm's length ("alligator skin" pattern); common . . . . . CONOCEPHALUM CONICUM

77b THALLUS SMALL TO MEDIUM SIZED, mostly less than 8 mm wide; areolation inconspicuous without lens

78a EPIDERMAL PORES COMPOUND, the pore formed by a barrel-shaped chamber that projects below the epidermis into the underlying air space (otherwise only in Marchantia); rare, to date only two records from OR . . . . . PREISSIA QUADRATA

78b EPIDERMAL PORES SIMPLE, composed of concentric rings or cells continuous with the epidermis

79a FEMALE RECEPTACLES CONIC OR HEMISPHERIC, usually more or less lobed; a delicate pseudoperianth surrounding each capsule with linear-lanceolate segments at maturity; many species, widespread and common . . . . . ASTERELLA

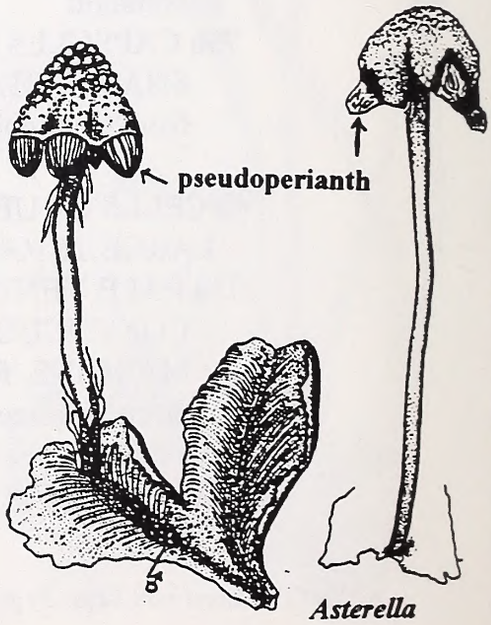
79b FEMALE RECEPTACLES DISK-SHAPED, the margin elaborated into a thin, horizontal, unlobed wing or rim; lacking a pseudoperianth; presently known only from along the lower Rogue River . . . . . CRYPTOMITRIUM TENERUM

Athalamia

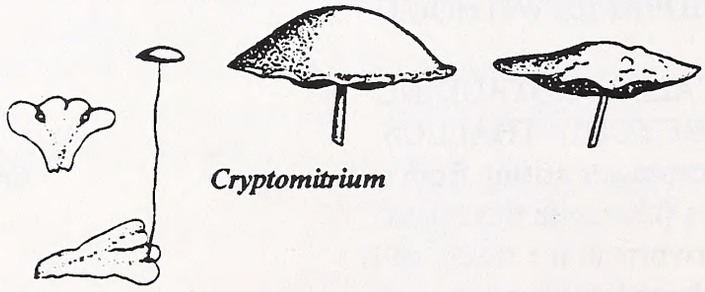
Conocephalum

Preissia

♀ ♂



Asterella



Cryptomitrium

KEYS TO SPECIES

Note: The only genera treated here are those which contain special species not keyed individually in the key to genera.

for BARBILOPHOZIA SEE LOPHOZIA

KEY TO CALYPOGEIA

1a OIL-BODIES DISTINCTLY BLUE . . . . . C. TRICHOMANIS
1b OIL-BODIES COLORLESS, clear, or slightly grayish
2a UNDERLEAVES ENTIRE OR EMARGINATE, typically (6) 7-10 or more cells along midline from sinus to rhizoid initial region, rounded at base, essentially non-decurrent . . . . . C. NEESIANA
2b UNDERLEAVES BIFID, OFTEN DEEPLY, typically only 2-5 (rarely 6-7) cells along midline, usually + or - decurrent
3a LARGE PLANTS, shoots generally 2.5 - 4 mm wide; oil-bodies usually with a grayish cast, composed of numerous granules; lobes of underleaves usually rounded . . . . . C. MUELLERIANA
3b SMALLER PLANTS, shoots less than 2.5 mm wide; oil-bodies clear, mostly composed of a few large globules, some unsegmented oil-bodies always present; lobes of underleaves typically obtuse to acute
4a CELLS FAIRLY LARGE, 32-45 X 48-60 µm in leaf middle; shoots from 1.5 to 2.4 mm wide; underleaves with widely spreading lobes, these often angled or toothed on the lateral margins; frequently on soil, sometimes on organic substrate; common and widespread . . . . . C. FISSA
4b CELLS SMALL, LESS THAN 45 µm in leaf middle (longest dimension); shoots smaller, 1.2 to 1.8 mm wide; lobes of underleaves not spreading, rarely toothed or angled; almost always on Sphagnum or on rotting wood; uncomon
5a RESTRICTED TO SPHAGNUM; underleaves rarely as much as twice as wide as the stems; midleaf cells 30-35 X 40- 45 µm; frequent presence of terminal branching . . . . . C. SPHAGNICOLA
5b FOUND ON ROTTING WOOD; underleaves usually 2-3 times as wide as the stem; midleaf cells 25 X 30 µm; postical-intercalary branching only . . . . . C. SUECICA

KEY TO CEPHALOZIELLA

Note: This key has been adapted from Smith (1990). It is incomplete; it is designed to identify C. spinigera from others in the genus but not to identify all species. See Hong (1986) for keys to all species, being forewarned that species with dentate leaves are difficult to track in his keys. Smith's keys are also tricky, having reticulations as well as dichotomies.

1a LEAVES TOOTHED or at least some on sterile stems with 1-2 spinose teeth near base
2a UNDERLEAVES ABSENT from sterile stems, or if present, the leaf lobes 2-4 cells wide
3a LOBES OF LEAVES OF STERILE STEMS 6-12 CELLS WIDE; gemmae angular; abundant on soil or burnt wood . . . . . C. TURNERI
3b LOBES MOSTLY 2-4 CELLS WIDE; gemmae smooth
4a CELLS AT BASE OF LEAF LOBES OF STERILE STEMS MOSTLY 8-13µ; teeth of female bracts neither spinose nor recurved . . . . . C. SPINIGERA
4b CELLS AT BASE OF LEAF LOBES 13-20µ; bract teeth often spinose and recurved . . . . . C. ELACHISTA
2a UNDERLEAVES PRESENT; leaf lobes 4-9 cells wide at base . . . . . OTHER SPECIES
1b LEAF MARGINS OF BOTH STERILE AND FERTILE STEMS ENTIRE ... " "

KEY TO CHILOSCYPHUS IN OREGON

1a GEMMAE PRODUCED IN FASCICLES FROM LEAVES OF SHOOT APEX; rhizoids scattered (thus not truly a Chiloscyphus) . . . . . C. GEMMIPARUS
1b GEMMAE LACKING; rhizoids localized at base of underleaves
2a OIL BODIES MOSTLY 2 PER CELL, rarely 3 or more; dark olive green, on sticks or rocks, usually submerged . . . . . C. POLYANTHOS
2b OIL BODIES MOSTLY MORE THAN 4 PER CELL; pale whitish green, on soil or organic substrate near water . . . . . C. PALLESCENS

KEY TO DIPLOPHYLLUM

1a LEAVES WITH STRONGLY DECURRENT BASES, vittate; cells with nodular trigones; rare . . . . . D. PLICATUM
1b LEAVES WITHOUT DECURRENT BASES, vittate or not; cells with trigones poorly developed; common; habitats various
2a LEAVES WITH CENTRAL STRIPE OF ELONGATED CELLS (VITTATE); usually on bark or wood, occasionally on soil . . . . . D. ALBICANS
2b LEAVES WITH CELLS MOSTLY ALIKE, LACKING CENTRAL STRIPE; usually on soil or rock, occasionally on peat
3a DIOECIOUS; GEMMAE ABUNDANT (except when fertile, when sexuality is obvious); most abundant inland and at high elevations . . . . . D. TAXIFOLIUM
3b PAROECIOUS; GEMMAE ABSENT AT ALL TIMES; male bracts not prominent; most abundant along coast but also present inland; however, uncommon at high elevations . . . . . D. OBTUSIFOLIUM

KEY TO GYMNOMITRION

1a LEAVES BILOBED, THE LEAF LOBES ACUTE; plants yellow brown to dull whitish-green; cuticle smooth . . . . . G. CONCINNATUM
1b LEAF LOBE TIPS ROUNDED; plants silvery- to whitish-green; cuticle smooth or papillate

2a LEAVES BILOBED FOR 0.05-0.15 THEIR LENGTH; cuticle smooth; margins entire; marginal cells thin-walled; rare . . . . . G. CORALLOIDES

2b LEAVES BILOBED FOR 0.15-0.25 THEIR LENGTH; cuticle papillate; margins crenulate; marginal cells thick-walled; common . . . . . G. OBTUSUM

KEY TO BARBILOPHOZIA and LOPHOZIA

Note: Recognized as a single genus by he writer, it is the largest and most difficult genus in the region. Differentiation of species is frequently based on rather technical characters; sterile material may be quite indeterminable, likewise dried material lacking oil-bodies. Common species are indicated with an asterisk (*). Identification of the other species keyed here should always be verified by further study in technical manuals, such as Schuster (1969), comparison with authentic material, and /or examination by an expert. Note that all species presently reported from the Pacific Northwest are treated in Schuster, i.e., all are known from eastern North America, also. There are, however, some unidentified species of Lophozia from our area which are either undescribed endemics or disjuncts from other continents.

1a OIL-BODIES NUMEROUS, 15-50 PER CELL, MINUTE (smaller than the chloroplasts), homogeneous; leaves occasionally 3-lobed . . . . . subgen. MASSULA

2a UNDERLEAVES FREQUENT, although inconspicuous (laciniate-ciliate when well-developed); leaves with the lobes obtuse to rounded, bilobed; stems slender, more round than elliptical; gemmae rare . . . . . L. OBTUSA

2b UNDERLEAVES ABSENT; leaves frequently dentate-lobed, often tri-lobed, the lobes acute; stems usually fleshy, broad and flattened; gemmae abundant

3a GEMMAE OVOID-SPHERICAL, 1-celled; usually on Sphagnum; stem underside and rhizoids usually intensely purplish-red . . . . . L. LAXA

3b GEMMAE ANGULATE, 1-2 CELLED; not on Sphagnum; plants pale green throughout

4a PERIANTH MOUTH WITH ABUNDANT TEETH 1-3 (4) CELLS LONG, the longer cells thick-walled; spores (10) 12-15 µm; leaves 1 or rarely 2-3 stratose at base; common on decaying wood at all elevations . . . . . L. INCISA *

4b PERIANTH MOUTH SUBENTIRE TO DENTICULATE, the teeth 1 celled and not greatly thickened; sopres mostly 18-21 µm; leaves 2-3 or 4-5 statose at base; abundant on peaty soil at high elevations . . . . . L. OPACIFOLIA*

1b OIL-BODIES USUALLY FEWER THAN 12 PER CELL, if more then distinctly granulose and larger than the chloroplasts; leaves bilobed or 3-4 lobed

5a LEAVES MOSTLY 3-4 LOBED; underleaves usually conspicuous . . . . . (subgen.) BARBILOPHOZIA

6a UNDERLEAVES RELATIVELY SMALL AND INCONSPICUOUS; cilia lacking on ventral leaf bases; gemmae (rare or) absent. (Reported only from Saddle Mt.) . . . . . B. BARBATA

6b UNDERLEAVES LARGE, PROMINENT, PRESENT THROUGHOUT; 1-several cilia present on ventral leaf base margin; gemmae sometimes present

7a MEDIUM-SIZED PLANTS, USUALLY 1.5-2.7 MM WIDE; leaf tips largely acute or acuminate rather than mucronate; cilia at leaf base with cells averaging 3-6 times as long as wide; gemmae frequent; . . . . . B. HATCHERI*

7b ROBUST PLANTS, 3.5-5 MM WIDE; leaf tips usually clearly mucronate; cilia at leaf base with cells averaging 6-10 times as long as wide; gemmae rare . . . . . B. LYCOPODIOIDES

5b LEAVES CONSISTENTLY BILOBED; underleaves present or not, rarely conspicuous

[Not treated here are the "Dilophozias," a large and rich assemblage of species. None of these are presently listed as being of conservation concern. Several are potential candidates for listing but too little is known about them to propose listing at this time.]

KEY TO MARSUPELLA

Note: This genus is difficult to work with because of the small size of the plants included. The only common taxon is M. emarginata var. emarginata. The following key is adapted from Hong (1982). It is not easy to use because of its reliance on sexuality in the first couplet, meaning one must find fertile plants and dissect out the sex organs. The size differences are not always as sharp as the key suggests.

1a PLANTS PAROECIOUS

2a PLANTS 1.0 - 3.0 CM HIGH; purplish brown or blackish to blackish-brown; on soil . . . . . M. SPARSIFOLIA

2b PLANTS 0.1 - 1.0 CM HIGH; dark green, dull brown to reddish-brown

3a PLANTS 0.1-0.5 CM HIGH; dark green to brownish-black; leaves spreading-suberect; leaf lobes acute to subacute . . . . . M. SPRUCEI

3b PLANTS 0.5 - 1.0 CM HIGH; reddish-brown; leaves erect-appressed; leaf-lobes subacute to rectangular . . . . . M. BREVISSIMA

1b PLANTS DIOECIOUS

4a PLANTS FILIFORM; LEAVES SCALELIKE . . . . . M. CONDENSATA

4b PLANTS NOT FILIFORM; LEAVES NOT SCALELIKE BUT FREE AT THE TIPS

5a PLANTS 0.5 - 1.0 CM HIGH; LEAVES STRICTLY TRANSVERSELY INSERTED; leaves divided for 0.2-0.3 their length; trigones large . . . . . M. COMMUTATA

5b PLANTS 0.5-10 CM HIGH; LEAVES USUALLY SOMEWHAT SECUND; leaves divided for 0.1-0.6 their length; trigones small to bulging

6a LEAVES DIVIDED FOR 0.05-0.3 THEIR LENGTH; leaf-sinus absent to broad; leaf-margins slightly reflexed or involute

7a PLANTS GREEN OR WITH RED PIGMENTS (black in M. emarginata var. aquatica); leaves not conspicuously concave, with reflexed margins; 0.1-0.3 bilobed; leaf-sinus broad, obtuse; chiefly nonarctic . . . . . M. EMARGINATA

8a PLANTS TERRESTRIAL, only seasonally (if ever) submerged; green to reddish-brown; widespread and common . . . . . var. EMARGINATA

8b PLANTS AQUATIC; always submerged; nearly black; rare . . . var. AQUATICA

7b PLANTS COPPER-RED TO BLACKISH; leaves cupped or saucer-like, with involute margins; 0.05-0.1 bilobed; leaf-sinus absent or vestigial; arctic . . . . . M. ARCTICA

6b LEAVES DIVIDED FOR 0.3-0.6 THEIR LENGTH; leaf-sinus acute; leaf margins plane

9a PLANTS UP TO 5 CM HIGH, deep dull green, brownish above; leaf-lobes broadly

rounded (subacute in fo. media), leaves 0.3-0.6 bilobed; rhizoids few ..... M. SPHACELATA

9b PLANTS UP TO 0.5 CM HIGH; red-green to dark-red; leav lobes acute to obtuse; leaves 0.2-0.35 bilobed; rhizoids numerous ..... M. BOLANDERI

KEY TO NARDIA

Note: only N. geocyphus and N. scalaris are relatively common, the latter occurring down to sea level. The others keyed here were found in Oregon, at high elevations, only relatively recently.

1a. OIL-BODIES SOLITARY, 1 PER CELL (looking like lumps of translucent oatmeal); minute plants only a few mm tall, to .5 mm wide; the leaves bilobed ..... N. BREIDLERI

1b. OIL-BODIES 2 OR MORE PER CELL; plants mostly larger; leaves entire or bilobed

2a OIL-BODIES HOMOGENEOUS, GLISTENING (some becoming segmented)

3a LEAVES BILOBED THROUGHOUT ..... N. JAPONICA

3b LEAVES ENTIRE, OCCASIONALLY RETUSE ON ROBUST SHOOTS ... N. scalaris

2b OIL-BODIES GRANULOSE, COMPOSED OF NUMEROUS FINE GLOBULES

4a LEAVES BILOBED THROUGHOUT ..... N. INSECTA

4b LEAVES ENTIRE TO RETUSE (EMARGINATE) ..... N. GEOSCYPHA

KEY TO PLAGIOCHILA

Note: The following key is adapted from Hong (1992). Difficulty may arise when attempting to using this key for the separation of P. satoi from P. asplenioides. Many specimens are not clearly differentiated by the characters described here. This is in part due to the lack of resolution of taxonomic problems in the P. asplenioides - porelloides complex.

1a LEAF SURFACE SHINY, appearing as if varnished when dry; with a band of elongated cells (a vitta) at median leaf base ..... P. SEMIDECURRENS

1b LEAF SURFACE DULL TO GLOSSY, NOT SHINY; vitta weak or absent

2a LEAVES WITH SMALL AREA OF VITTA CELLS; margins spinose-dentate but occasionally entire, the teeth 2-5 cells long and 1-4 cells wide at base; trigones moderate; perianth mouth irregularly dentate to spinose-dentate ..... P. SATOI

2b LEAVES LACKING VITTA CELLS; margins entire to dentate, the teeth (if present) 1-3 cells long and 1-2 cells wide at base; trigones moderate to slightly bulging; perianth mouth entire to ciliate-dentate ..... P. ASPLENIOIDES (includes P. porelloides)

KEY TO PORELLA

1a Plants with peppery-acrid taste; ventral lobes of lateral leaves narrowly triangular, mostly plane, the apex directed parallel to the stem; decurrent portion of underleaves and ventral lobes crispate-convoluted, often developed into paraphyllia; perianth mouth broad, toothed on margin; common and widespread in Oregon ..... P. ROELLII

1b Plants with aromatic taste but not peppery-acrid; ventral lobes of lateral leaves ovate or broadly triangular, the apex spreading at an angle from the stem; decurrent portion of underleaves and ventral lobes plane (but sometimes toothed); perianth mouth narrow, edentate (taste, perianths unknown in P. fauriei in Oregon)

2a Leaves and underleaves regularly and prominently toothed, especially noticeable on ventral lobes of lateral leaves; rare in the region

3a Ventral lobes decurrent; underleaves triangular, only slightly wider than stem; leaves typically densely undulate-imbricate, speading; in Garry oak zone .... P. BOLANDERI

3b Ventral lobes hardly decurrent; underleaves ovate, twice as wide as stem; leaves imbricate but not undulate, +/- ascending; found only once in Columbia River Gorge . P. FAURIEI

2b Leaves and underleaves entire or with occasional rare teeth; common species

4a Underleaves and ventral lobes with a tight, narrow revolute margin; ventral lobes ovate with smoothly rounded margins; underleaves close, often overlapping, the free portion approximately equal to the decurrent portion ..... P. NAVICULARIS

4b Underleaves and ventral lobes with plane margins; ventral lobes roughly triangular, with irregular, +/- straight margins, the outher margin curled in (but not tightly revolute); underleaves distant, stem usually visible between them, the decurrent portion usually much longer than the free portion ..... P. CORDAEANA

KEY TO PTILIDIUM

1a LEAVES COMMONLY 1-3 CILIATE ..... P. CALIFORNICUM

1b LEAVES MOSTLY MANY CILIATE ..... P. PULCHERRIMUM AND P. CILIARE

KEY TO RADULA

1a PLANTS DARK BROWN; tiny branchlets produced in the axils of most leaves ..... R. BRUNNEA

1b PLANTS PALE, SOFT GREEN; branches only of normal kind

2a DIOECIOUS; dorsal lobe adnate to stem along inner margin; oil bodies nearly filling the cells ..... R. BOLANDERI

2b PAROECIOUS (male bracts conspicuous below perianths); dorsal lobe free, arching over the stem; oil-bodies with space around them equal to half their width .. R.COMPLANATA

KEY TO SCAPANIA

Note: when examining plants for decurrent leaves, use upper leaves of robust individuals for best interpretation.

1a ONE LARGE, BROWN, PLATE-LIKE OIL-BODY PER CELL (RARE) ..... S. GYMNOSTOMOPHILA

1b TWO OR MORE OIL-BODIES PER CELL

2a TEETH OF DORSAL LOBE MORE THAN TWICE AS COARSE AS TEETH OF

VENTRAL LOBE; basal margin of dorsal lobe with compound cilia; often brownish but never red tinged (almost invariably on bark or rotten wood, very common) . . . . . S. BOLANDERI

2a TEETH OF +/- EQUAL SIZE ON BOTH LOBES, or leaves edentate; cilia absent at base of dorsal lobe though basal margins sometimes toothed; red pigmentation sometimes present

3a DORSAL LOBE WITH DECURRENT WING

4a KEEL STRONGLY ARCHED (plant + or - aquatic, rare) . . . . . S. PALUDOSA

4b KEEL STRAIGHT OR ONLY SLIGHTLY CURVED (usually with paraphyllia in axils of upper leaves; decurrent wing of dorsal lobe often convoluted and toothed; on rocks or soil, often near water though hardly aquatic, very common) . . . . . S. AMERICANA

3b DORSAL LOBE NOT DECURRENT

5a VENTRAL LOBE LONG DECURRENT

6a DORSAL LOBE ONLY SLIGHTLY SMALLER THAN VENTRAL LOBE (on soil or rock, usually near water, at higher elevations, rare)

7a PLANTS GREEN, often with reddish-brown tints; cell walls thickened in leaf margin; shoots usually 2 - 5 mm wide . . . . . S. SUBALPINA

7b PLANTS BLACKISH; marginal cell walls not thickened; shoots less than 1.5 mm wide . . . . . S. OBSCURA

6b DORSAL LOBE ONLY TWO-THIRDS OR LESS THE SIZE OF THE VENTRAL LOBE

8a LEAF LOBES GRADUALLY TAPERING TO APEX (dorsal lobe pointing forward; perianth mouth entire; leaves sharply & coarsely serrate; on wood, occasional) . . . . . S. UMBROSA

8b LEAF LOBES ROUND, APEX NOT TAPERED OR POINTED (variable from entire leaves to much toothed leaves; on soil or rocks, sometimes aquatic, common) . . . . . S. UNDULATA

5b VENTRAL LOBE NOT DECURRENT or only slightly so

9a LEAVES BORDERED WITH THICK-WALLED MARGINAL CELLS; marginal cells mostly lacking oilbodies (leaves usually broadly rounded, entire to obscurely dentate; on soil or rocks, rare) . . . . . S. CURTA

9b LEAVES WITHOUT A BORDER OF THICK-WALLED CELLS; oil- bodies in most cells

10a AQUATIC, ROBUST, USUALLY 1-5 CM LONG; 3-5 small oil- bodies per cell; entire to usually minutely toothed (near standing water, montane, rare) . . . . . S. IRRIGUA

10b NON-AQUATIC, SMALL USUALLY .6-1.2 CM LONG; 2-6 large oil bodies per cell, obscuring most of cell lumen (rare, on soil or rocks, coastal or coast mountains) . . . . . S. MUCRONATA

KEY TO SPHAEROCARPOS

1a MOUTH OF INVOLUCRES SMALL, incurved . . . . . S. TEXANUS

1b MOUTH OF INVOLUCRE LARGE, flaring . . . . . S. HIANS

KEY TO TRITOMARIA

Note: This key is taken with little change from Smith (1990).

1a GEMMAE RARE, YELLOWISH-GREEN; leaves undulate when moist, crisped when dry; lobes not toothlike . . . . . T. QUINQUEDATA

1b GEMMAE VERY COMMON, DEEP RED; leaves not undulate when moist nor crisped when dry; dorsal lobe lateral and tooth-like

2a GEMMAE ELLIPSOID, 12-19 µm LONG; cells in middle of leaf 12-18 µm wide . . . . . T. EXSECTA

2b GEMMAE OBTUSELY ANGLED OR PEAR SHAPED, 16-28 µm LONG; cells in middle of leaf 17-32 µm wide . . . . . T. EXSECTIFORMIS

Index to Liverwort Names in Keys

PART V. INDIVIDUAL SPECIES TREATMENTS: LIVERWORTS.

In the following treatments, size of shoot width of leafy liverwort is given by descriptive terms defined rather strictly. Although arbitrary and without any widely accepted standard, the values employed in these treatments are close to those generally used for the terms by liverwort specialists. Thallose liverworts are mostly larger and a different scale is needed to reflect the size terms used in current literature; numerical measurements are presented as needed.

SIZE STANDARDS FOR SHOOT WIDTH OF LEAFY LIVERWORTS

minute	<0.5 mm
small	0.5 - 1.5 mm
medium	1.5 - 2.5 mm
large	2.5 - 4 mm
robust	>4 mm

Note that genus descriptions are relatively sparse in these treatments. When a user is not familiar with a particular genus, he/she should work backwards through the key to genera (PART IV) to gain an appreciation for its diagnostic features.

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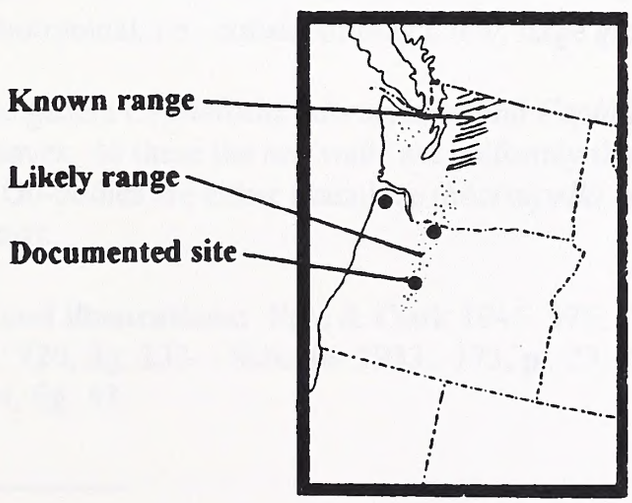
The following conventions are used in mapping distributions: dots for documented sites, from the literature or from examination of specimens and hatching for known range. The stippled areas are intended to show potential range ("where to look") and do not imply continuous distribution.



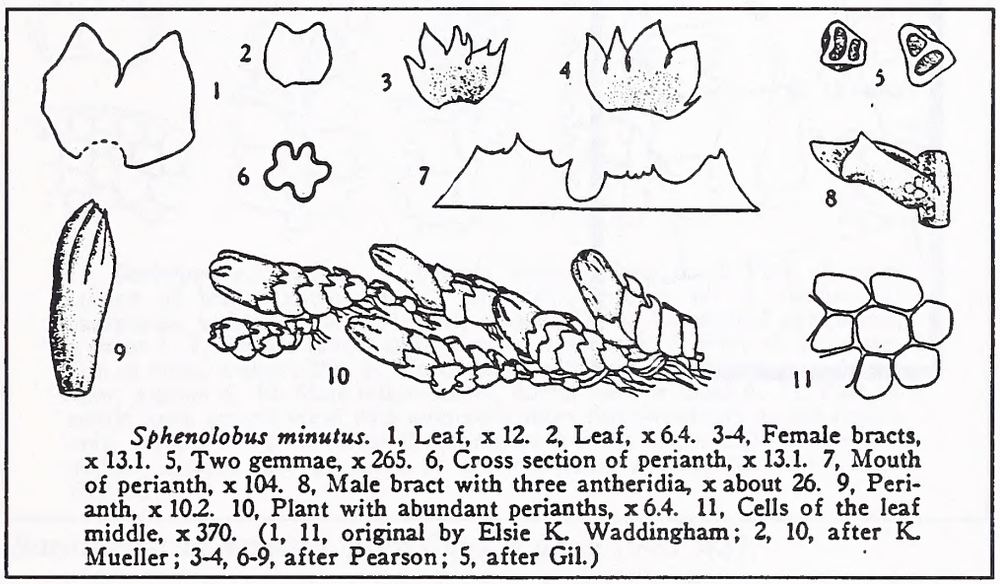
ANASTROPHYLLUM MINUTUM (Schreb. ex Cranz) Schust.
Little darkstar
Recent synonym: *Sphenolobus minutus* (Schreb. ex Cranz) Steph.

Status: ONHP List 3

Distribution: Circumboreal; British Columbia, Idaho, Cascade Mountains of Washington and Oregon.

Habitat/Ecology: On wet soil, rocky ledges or on wet rocks in subalpine or alpine zones. This species occurs in a variety of open sites whose vascular plant associates cannot be clearly characterized from current sources. It is probably more closely tied to microsite characteristics than it is to any particular vegetation type. This observation applies to most of the rare bryophytes found at higher elevations.

Description: Small plants, dark green to brown. Shoots usually less than 1mm wide, with transversely inserted, bilobed leaves. Stems typically erect and crowded.



Sphenolobus minutus. 1, Leaf, x 12. 2, Leaf, x 6.4. 3-4, Female bracts, x 13.1. 5, Two gemmae, x 265. 6, Cross section of perianth, x 13.1. 7, Mouth of perianth, x 104. 8, Male bract with three antheridia, x about 26. 9, Perianth, x 10.2. 10, Plant with abundant perianths, x 6.4. 11, Cells of the leaf middle, x 370. (1, 11, original by Elsie K. Waddingham; 2, 10, after K. Mueller; 3-4, 6-9, after Pearson; 5, after Gil.)

Anastrophyllum minutum from Frye & Clark 1945: 376.

Distinctive characters: Cell walls of leaves are conspicuously and evenly thickened (not thickened just at corners of cells). Oil-bodies are distinctly botryoidal, i.e., consist of only a few, large globules.

Similar species: The genera *Cephalozia*, *Marsupella*, and *Cephaloziella* all have species of small plants with bilobed leaves. In these the cell walls are uniformly thin or thickened only at the corners of the cells. Oil-bodies are either granulose (*Marsupella* and *Cephaloziella*) or absent altogether (*Cephalozia*).

Other descriptions and illustrations: Frye & Clark 1945: 375, *376*[1]. Kitagawa 1966: 129, fig. XXIX. Müller 1954: 720, fig. 233. Schuster 1953: 373, pl. 23. Schuster 1969: 757, fig. 244-246. Smith 1990: 124, fig. 53.

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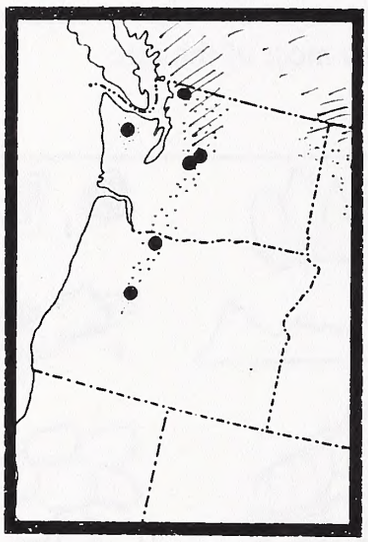
[1] Numbers in italics refer to page numbers where illustrations appear in references without numbered plates.

Notes/Comments: Tolerates full exposure, but usually on N-facing slopes.

Conservation Issues: Sites at the southern end of the range are in fairly remote alpine areas protected by wilderness status. Here the main threat is likely to be overcollection by bryologists. Having information of known sites being readily available should discourage re-collecting. Requiring scientific collecting permits provides a method of alerting researchers to avoid redundant collections. In Washington State some sites may be threatened by road-building or recreation. The roadside records would be worth trying to relocate to see if they were from undisturbed outcrops or roadcut exposures. If the latter, determining the length of time the substrate has been exposed would give an idea of how successful a pioneer this species might be.



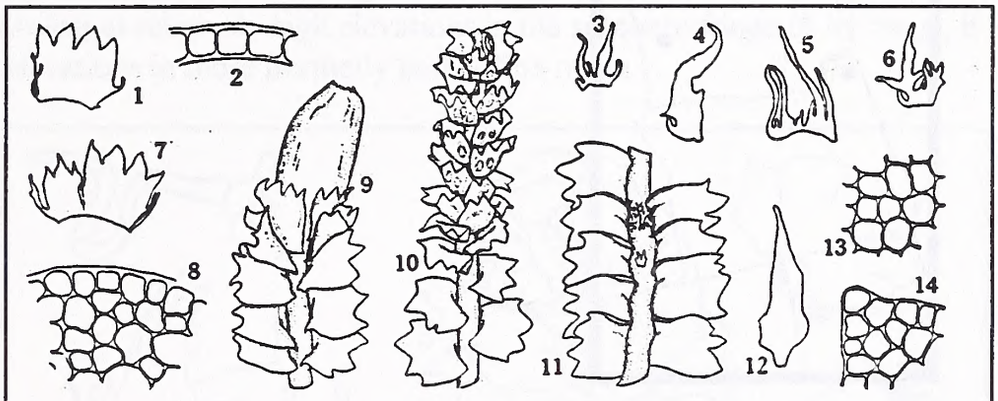
BARBILOPHOZIA BARBATA (Schmid.) Loeske
Lesser four point
Recent synonym: *Lophozia barbata* (Schmid.) Dum.

Status: ONHP List 3.

Distribution: Circumboreal; in Oregon known only from Saddle Mountain, Clatsop County.

Habitat/Ecology: Arctic-boreal peaty soil or organic substrate, often asociated with rock outcrops. Not known to be associated with particular vegetation type.

Description: Shoots medium to large (to 3.5 mm wide), dark green (drying brownish), sprawling. Branching infrequent. Leaves squarish, very obliquely inserted, spreading widely, overlapping closely, mostly 4-lobed (occ. 3 or 5 lobed). Underleaves (when present) deeply bilobed, sparsely ciliate. Odor of crushed plants "spicy-fragrant when alive and moist" (Crum 1991).



Barbilophozia barbata. 1, Female bract, x about 6. 2, Part of cross section of leaf, x about 106. 3, Underleaf, x about 17. 4, Antheridial paraphysis, x about 7. 5, Underleaf, x about 17. 6, Antheridial paraphysis, x about 7. 7, Female bracts and bracteole, x about 6. 8, Part of cross section of stem, x about 265. 9, Tip of plant with female inflorescence, dorsal view, x about 6. 10, Male inflorescence, dorsal view, x about 6. 11, Part of sterile stem, ventral view, with numerous short rhizoids shown at one region only, x about 7. 12, Antheridial paraphysis, x about 7. 13, Cells of the leaf middle, x about 106. 14, Cells of the leaf apex, x about 106. (All after Evans.)

Barbilophozia barbata from Clark & Frye 1945: 427.

Distinctive characters: Lobe tips rounded to barely acute. Underleaves absent or very small (for a *Barbilophozia*), inconspicuous. Gemmae absent.

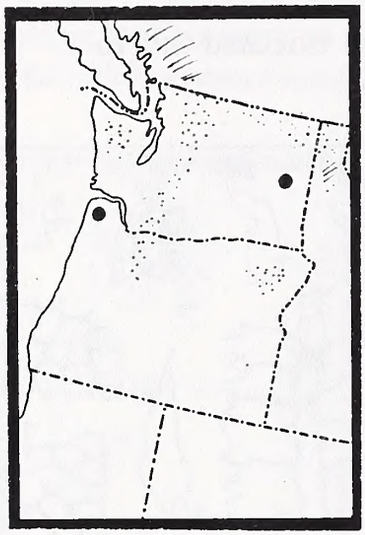
Similar species: *Barbilophozia hatcheri* (common) and *B. lycopodioides* (very rare) are very similar but both have pointed lobe tips, cilia on the postical (ventral) leaf bases, and well-developed underleaves with ciliate lobes. Reddish-brown gemmae are common on leaves at tips of shoots of *B. hatcheri* but generally absent on *B. barbata*.

Other descriptions and illustrations: Frye & Clark 1945: 426, *427*. Crum 1991: 68, fig. 63. Kitagawa 1965: 262, fig. IV. Müller 1954: 635, fig. 191. Schuster 1953: 328, pl. 5. Schuster 1969: 355, fig. 162. Smith 1991: 98, fig. 43.

Notes/Comments: Caution must be taken to avoid mistaking depauperate shoots of *B. hatcheri* for *B. barbata*. When not fully developed, *B. hatcheri* may not have distinctly pointed leaf lobes and the underleaves and cilia of postical leaf bases likewise reduced. Note that *B. barbata* is

normally quite as large as, or even larger than, typical *B. hatcheri.* Botanists searching for the rarer species would do well to first become familiar with the normal variations of the common species. Use of the name *Lophozia barbata* is recommended, since the boundaries between *Lophozia* and *Barbilophozia* are not sharp; the keys treat these as subgenera.

Conservation Issues: Little is known about the ecological requirements of this species.



BARBILOPHOZIA LYCOPODIOIDES (Wallr.) Loeske
Giant fourpoint, maple liverwort
Recent synonym: *Lophozia lycopodioides* (Wallr.) Cogn.

Status: ONHP List 3.

Distribution: Circumboreal. In Oregon from Saddle Mountain, Clatsop County and Anthony Lakes area, Grant County.

Habitat/Ecology: This species grows on peaty soil or on decomposed organic detritus in areas with boreal affinities, i.e. forested areas subject to regular snowfall. It is often associated with cliffs or rock outcrops. Growing at relatively high elevations in the southern fringe of its range, it occurs at lower and lower elevations in more northerly parts of its range.

Description: Large (to 4 mm wide), pale green to yellowish green, sprawling shoots turned up at shoot apex. Leaves overlapping closely, wider than long, obliquely inserted and spreading widely, usually 4-lobed (occasionally 3- or 5-lobed). Lobes separated by shallow sinuses; lobe tips with mucronate tips, the mucro several cells long. Sinuous cilia present at postical leaf base. Underleaves deeply bifid, with ciliate margins.

Barbilophozia lycopodioides. 1, Cilium from base of leaf, x 151. 2, Underleaf, x 29. 3, Tip of plant, dorsal view, x 8.5. 4, Leaf, x 8.5. 5, Leaf and underleaf (*u*), x 4.2. 6, Cells of the leaf middle, x 150. (5, after K. Mueller; others original, by Elizabeth Curtis.)

Barbilophozia lycopodioides from Frye & Clark 1945, p. 429.

Distinctive characters: A large, pale yellowish-green leafy liverwort with ruffled, shallowly 4-lobed leaves. Lobe tips obtuse but with long point. Gemmae usually absent. Cells of cilia at leaf base elongated, the longest usually more than 7 times longer than wide.

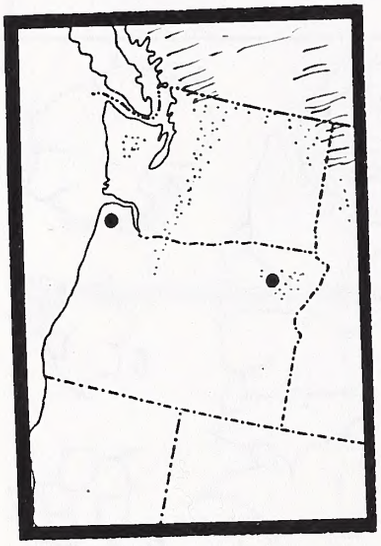
Similar species: *Barbilophozia hatcheri*, the common species in this genus, is smaller, usually has red-brown angular gemmae at shoot tips, has leaves more deeply lobed with acute lobe tips; and basal cilia with shorter cells (not more than 5 times longer than wide). Compare Fig. 157 (p. 338) and Fig. 160 (p. 348) in Schuster 1969.

Other descriptions and illustrations: Frye & Clark 1945: 428, *429*. Kitagawa 1965: 264, fig.

V. Müller 1954: p. 633, fig. 190. Pojar and MacKinnon 1994: p. 439 (with color plate). Schuster 1969: p. 337, figs. 157-159. Smith 1990: p. 98, fig. 42. Vitt et al. 1988: p. 147 (with color plate).

Notes/Comments: Botanists searching for this will find *B. hatcheri* most often in suitable habitats. Familiarity with the common species will make one immediately alert to the rarer species when it is encountered. Use of the name *Lophozia lycopodioides* is recommended; the keys treat *Lophozia* and *Barbilophozia* as subgenera.

Conservation Issues: Recreation and overcollection are the primary threats to this rare species. Searching for this species in suitable sites, coupled with study at known sites, might result in the conclusion that this species requires no special management actions.



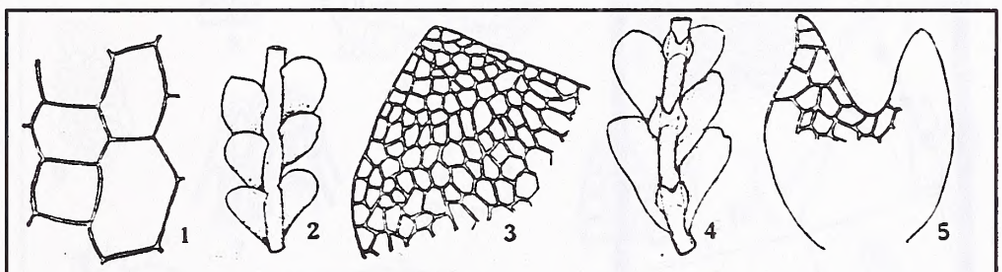
CALYPOGEIA SPHAGNICOLA (H. Arn. & Perss.) K. Muell.
Bog pouchwort
Recent synonym: *Calypogeja* is a variant spelling that has been frequently used for the genus. The conservation of *Calypogeia* was approved by the International Botanical Congress in Berlin (Taxon 37:439. 1988).

Status: ONHP List 2.

Distribution: Northern Europe across North America to Japan (Schuster 1969). In Oregon known mostly from near the coast but also at least a few sites in the western Cascades, Linn and Lane County.

Habitat/Ecology: Restricted to *Sphagnum* containing wetlands; specifically reported on *S. fuscum, S. henryense, S. nemoreum,* and *S. rubellum.* Other liverworts found here are *Cephalozia connivens, C. lunulifolia,* and *Mylia anomala.* Vascular plants reported in association include *Drosera, Darlingtonia, Tofieldia, Ledum, Carex, Typha, Myrica, Kalmia, Spiraea, Trientalis, Vaccinium,* etc.

Description: Small, pale whitish-green shoots growing over *Sphagnum*, in small patches or scattered strands. Leaves incubous, barely overlapping to (more typically) widely spaced. Underleaves bifid one-third to halfway, the outer margins rounded.

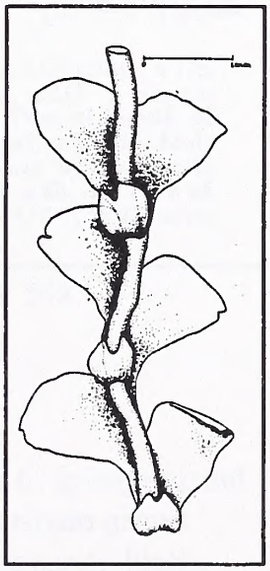


Calypogeia sphagnicola. 1, Median leaf cells, x 267. 2, Part of plant, dorsal view, x 8.5. 3, Cells of leaf tip, x 61. 4, Part of plant, ventral view, x 8.5. 5, Underleaf, x 61. (All original, by Sylvia Edmonds.)

Calypogeia sphagnicola from Frye & Clark 1946, p. 681.

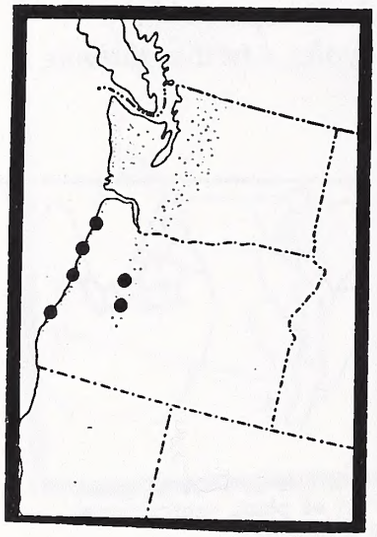
Distinctive characters: Restricted to *Sphagnum*. Leaves widely spaced, spreading only about 45°; leaf apex tending to be pointed. Oil-bodies composed mainly of few, 1-3, segments.

Similar species: Could be confused with either *C. muelleriana* or *C. fissa*, which can also occur on *Sphagnum* (although both of these common species are typically found on soil or organic substrates). *Calypogeia muelleriana* has heterogeneous oil-bodies (composed of different sized, small globules) which look like well-chewed pieces of chewing gum; its underleaves are only shallowly bilobed. *Calypogeia fissa* is darker (but still pale green) and has more closely overlapping leaves. The Oregon race has oil-bodies much like those of *C. sphagnicola*, with few segments. The underleaves of *C. fissa* are deeply bifid and usually have a shoulder or bump on the outer margin.


C. sphagnicola

Other descriptions and illustrations: Crum 1991: p. 65, fig. 59. Frye & Clark 1946: 680, *681*. Hong 1990, p. 317. Müller 1957: p. 1171, fig. 452. Schuster 1953: 541, pl. 65. Schuster 1969: p. 133, figs. 108-111. Smith 1990: p. 41, fig. 14.

Conservation Issues: There has undoubtedly been significant loss of this species to harvesting activity because of a general lack of general protection of *Sphagnum*-containing wetlands in the earlier parts of this century. *Sphagnum* is nowhere sufficiently abundant in Oregon to warrant commercial harvest permits any more. Sites at particular risk appear to be small bogs in the Western Cascades. It has been observed that logging up to the edge of small bogs causes catastrophic degradation and drastic loss of bog species. There has also been loss of open bog habitat in coastal areas due to natural succession. Some have suggested that this might be in part due to suppression of fires but little is known of the fire history of these bogs. This would be a fertile area of research for a palynologist.



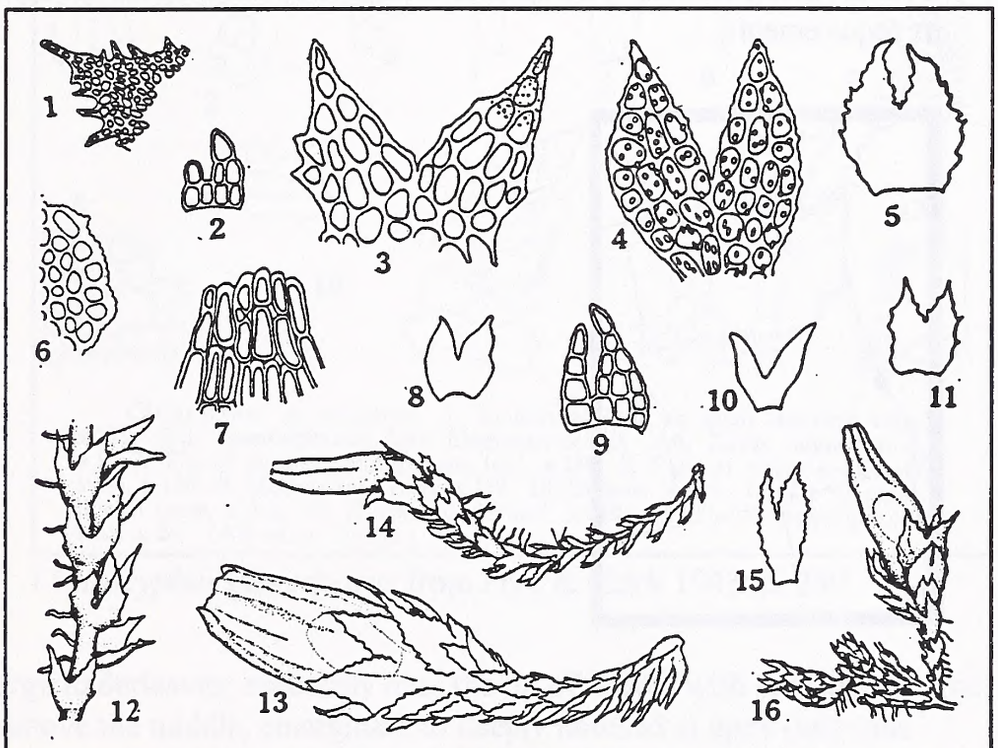
CEPHALOZIELLA SPINIGERA (Lindb.) Joerg.
Toothed tinythread
Recent synonyms: *Cephaloziella subdentata* Warnst. *Cephaloziella striatula* (C. Jens.) Douin

Status: ONHP List 3.

Distribution: Circumboreal; in both eastern and western North America. In Oregon only in coastal area. Reported from California (Hong 1986).

Habitat/Ecology: Restricted to *Sphagnum* containing wetlands, usually growing in full sun. Habitat characteristics seem to be very similar to *Calypogeia sphagnicola*, but this is not nearly as widespread.

Description: Shoots minute, ca 0.2 mm in diameter; light green to copper red in color. Leaves rather widely spaced along the stem, transversely inserted, bilobed more than halfway, often with one or more teeth along the lower margin. Underleaves usually present on sterile shoots but very small and inconspicuous. Perianths common, the female bracts prominently dentate.



Cephaloziella striatula. 1, Tip of female bract, x 83. 2, Underleaf, x 175. 3, Leaf, with verruculae shown at right tip, x 222. 4, Leaf, x 217. 5, Female bract, x 48. 6, Part of cross section of stem, x 175. 7, Part of mouth of perianth, x 217. 8, Leaf, x 58. 9, Underleaf, x 175. 10, Leaf, x 58. 11, Male bract, x 48. 12, Part of sterile stem, x 58. 13, Part of plant with perianth, x 39. 14, Shoot with perianth, x 27. 15, Female bracteole, x 48. 16, Part of plant with perianth and several male branches, x 27. (2, 4, 6-7, 9, 13, after Jensen; the others after K. Mueller.)

Cephaloziella spinigera from Frye & Clark 1945 p. 548.

Distinctive characters: Easily overlooked, tiny plants on *Sphagnum*. Teeth on stem leaves are diagnostic, but often missing. The dentate female bracts stand out. Cuticle of leaf surface is papillose.

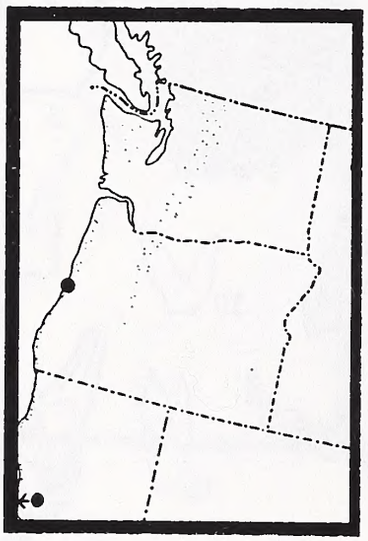
Similar species: Only one common species, *C. divaricata*, is the same size as *C. spinigera* and also has underleaves consistently present on sterile shoots. *Cephaloziella divaricata* grows mostly on rocks or rotting wood, especially burned wood, and is usually dark green to black,

rarely has a papillose cuticle, and has sinuous but not strongly dentate female bracts. *Cephaloziella turneri* has dentate leaves and bracts, but is much larger (0.5 mm in diameter), lacks underleaves, and usually grows on bare soil or charred wood. Separation of *Cephaloziella spinigera* from *C. elachista*, a larger species reported from the region, is best done by comparison with authentic specimens.

Other descriptions and illustrations: Crum 1991: p. 83, fig. 79. Frye & Clark 1945: p. 547, *548*. Hong 1986: p. 156. Müller 1957: p. 1025, fig. 380. Schuster 1953: p. 486, pl. 52. Schuster 1980: p. 68, figs. 492-494. Smith 1990: p. 74, fig. 31 (excellent).

Notes/Comments: The papillae of the leaf cuticle are very small and visible only by careful focusing on a leaf surface at high magnification.

Conservation Issues: This species is rarer than *Calypogeia sphagnicola* but otherwise similar in its requirements.

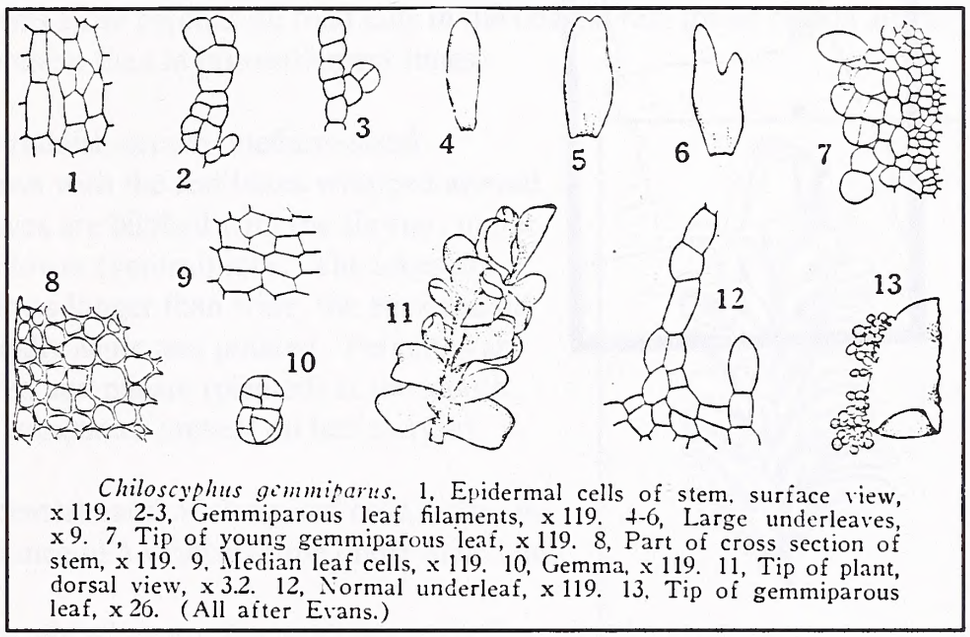


CHILOSCYPHUS GEMMIPARUS Evans
Alpine waterwort
Recent synonym: none

Status: ONHP List 1.

Distribution: Only five localities are known worldwide: two in Oregon and one each in Alaska, California, and Utah.

Habitat/Ecology: Attached to rocks in the bed of cold water streams, submerged or emergent in the splash zone.



Chiloscyphus gemmiparus. 1, Epidermal cells of stem, surface view, x 119. 2-3, Gemmiparous leaf filaments, x 119. 4-6, Large underleaves, x 9. 7, Tip of young gemmiparous leaf, x 119. 8, Part of cross section of stem, x 119. 9, Median leaf cells, x 119. 10, Gemma, x 119. 11, Tip of plant, dorsal view, x 3.2. 12, Normal underleaf, x 119. 13. Tip of gemmiparous leaf, x 26. (All after Evans.)

Chiloscyphus gemmiparus from Frye & Clark 1943: p. 249.

Description: A medium to large leafy liverwort, dark greasy-green in life, drying blackish. Shoots of two kinds, prostrate and erect. Prostrate shoots generally closely appressed to rock substrate, attached by numerous rhizoids and lacking underleaves or sex organs. Leaves attached obliquely on prostrate shoots, overlapping only slightly. Erect shoots have nearly transversely attached leaves, generally lack rhizoids but usually have large underleaves, especially near the tip of shoots with sex organs. The leaves are obovate, widest above the middle, emarginate to deeply notched at apex (and thus shallowly bilobed). Underleaves varying from tiny, finger-like projections to quite as large, and of the same form as, the lateral leaves. Gemmae produced in masses along the edge of leaves at shoot tips, composed of 2-5 cells at maturity. Typical fertile shoots bisexual, the antheridia in bracts immediately below the archegonial tip (paroecious). Unfertilized shoots often producing small, adventitious male shoots. Perianths produced only out of water, in the splash zone, after fertilization. Perianths oblong, closed at the mouth, with five longitudinal furrows or pleats.

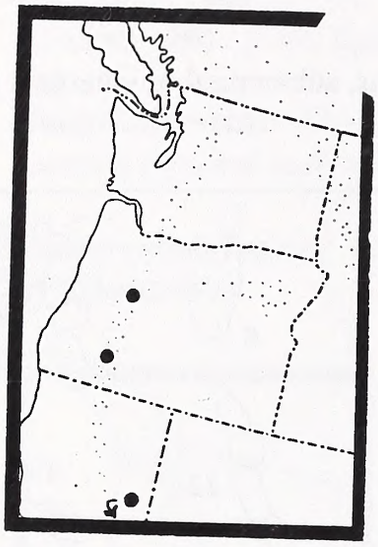
Distinctive characters: Our only aquatic leafy liverwort with abundant gemmae. An association with rocks in cold, fast moving water is characteristic.

Similar species: *Jungermannia exsertifolia* is very similar, a common aquatic in upper elevation streams. This has uniformly ovate leaves with rounded tips, readily noted in the field with a hand lens. It never produces gemmae. *Chiloscyphus gemmiparus* invariably has shoots showing

evidence of gemmae production recognizable with a hand lens. The lack of underleaves in the *Jungermannia* is a good microscopic character to distinguish it from *C. gemmiparus*.

Other descriptions and illustrations: Frye & Clark 1943: p. 249, *249*.

Conservation Issues: see comments under *Marsupella emarginata aquatica*.



DIPLOPHYLLUM ALBICANS (L.) Dum.
Striped foldedleaf
Recent synonyms: none

Status: ROD Table C-3.

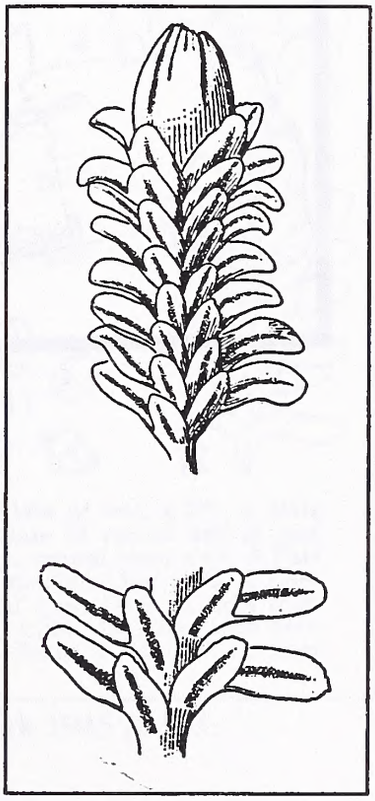
Distribution: Circumboreal. In western North America found mainly along the coast, in the Coast Range, and in the Cascade Mountains, south to Oregon.

Habitat/Ecology: On rotting logs, bark, wet rocks and mineral soil in the western hemlock/western redcedar and Sitka spruce forest zones. Under natural conditions this species occurs mainly on large woody debris in late successional forests and in small patches on streambanks. It now also forms large patches on road cuts in the coastal rain forest region and is probably more abundant at present than in pre-settlement times.

Description: Dark green to reddish-brown, medium-sized liverworts. Leaves in two rows with the leaf bases wrapped around the side of the stem. The leaves are bilobed with the shorter, upper (dorsal) lobe folded over the lower (ventral) lobe. The lobes are parallel sided, two to three times longer than wide, the apex usually round and obtuse or occasionally acute and pointed. Perianths are frequently produced, narrowed and plicate (pleated) at the mouth. Angled, bumpy gemmae are sometimes present on leaf margins.

Distinctive characters: A central band of elongated cells (vitta) in the leaf lobes give the appearance of a whitish stripe under hand lens.

Similar species: The closely related genus *Scapania* has several species possibly encountered in similar habitats, but all of these have a very sharp keel on the fold between the dorsal and ventral lobes. Two other species of *Diplophyllum* are common in the region but neither have the vitta. *Diplophyllum plicatum* is a rare species which also has a vitta in its leaf lobes, but its leaf bases are sheathing-decurrent and its leaf cells have knot-like trigones (see next species treatment).



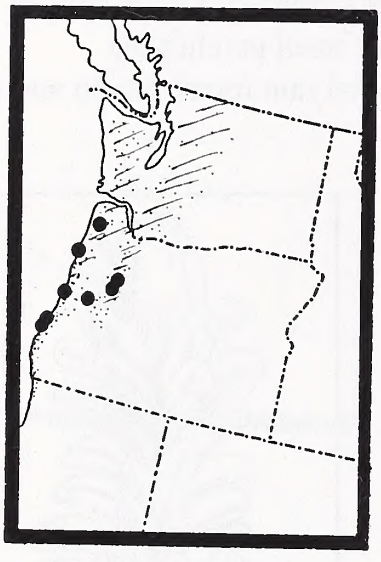
Diplophyllum albicans from Sanborn 1929: pl. V figs 6&7.

Other descriptions and illustrations: Frye & Clark 1946: p. 585, *586*. Müller 1957: p. 907, fig. 322. Pojar and MacKinnon 1994: p. 442 (color photos). Vitt et al. 1988: p. 150 (color photo).

Notes/Comments: This species represents a suite of liverworts that thrive on rotting logs in old-growth forests. Several others of these could have been chosen to represent this guild: *Calypogeia azurea, C. suecica, Cephalozia lunulifolia, Geocalyx graveolens, Lophocolea cuspidata,* or *Scapania umbrosa*. All are excellent indicators of microhabitat changes and widespread throughout the region.

Conservation Issues: This species is abundant in forested regions but its ability to flourish on inorganic as well as organic substrates indicates that it is not tied to old growth forests. This habitat preference has become clearer in recent investigations. This species is likely to persist as long as there are shady, cool, moist habitats; old roadcuts suffice.

Diplophyllum albicans (and other characteristic species such as *Scapania umbrosa*) represents the guild of liverworts that populate rotting logs in moist, ecologically robust forests, especially old-growth conifer forests of the Pacific Northwest. Their presence is a good indicator for assessing environmental health.



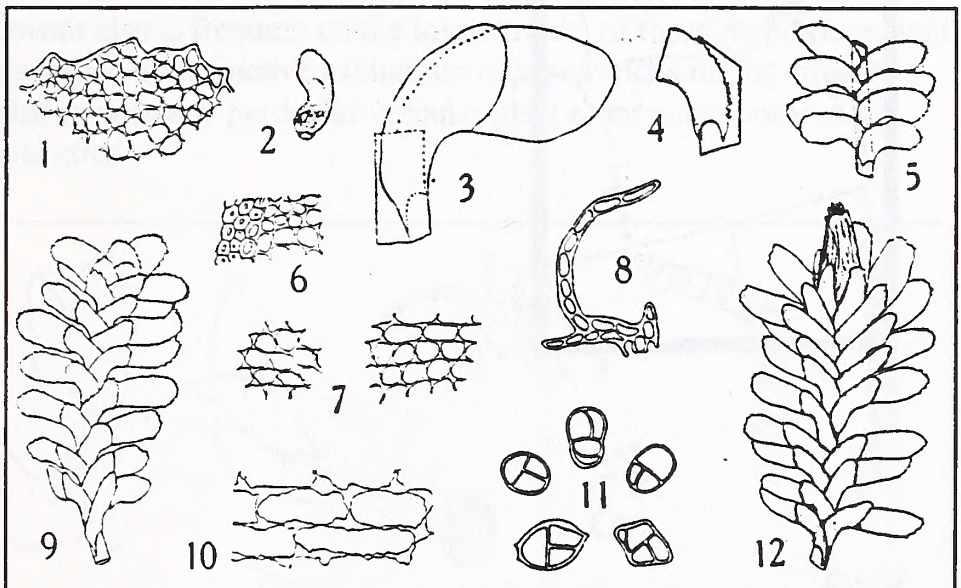
DIPLOPHYLLUM PLICATUM Lindb.
Giant foldedleaf
Recent synonym: *Macrodiplophyllum plicatum* (Lindb.) Perss.

Status: ONHP List 3; ROD Table C-3; Final SEIS Table J2-8a.

Distribution: North Pacific, from NE Asia around coastal Alaska and British Columbia south to northern Oregon.

Habitat/Ecology: Always in places where humidity is high and temperatures cool throughout the year. Substrates may vary from organic (bark, rotting wood, humus) to inorganic (mineral soil or rock).

Description: Large, dark green plants with two rows of bilobed, folded leaves. Lobes 2-4 times as long as wide. Lobes with parallel sides and a round to obtuse tip. There is a well developed band of elongated cells (vitta) in each lobe and all the leaf cells have pronounced rounded thickenings of the cell walls at the cell corners (nodose trigones). The margins of the leaves, at both front and back, extend down the stem past the point where the fold is attached (decurrent wings).

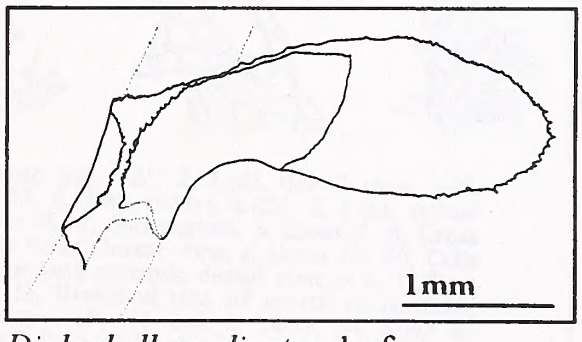


Diplophyllum plicatum. 1, Tip of ventral lobe of leaf, x 127. 2, Male bract, x 4.9. 3, Leaf, dorsal view, x 17.8. 4, Base of ventral half of leaf showing dentate margin, x 9.9. 5, Part of shoot, ventral view, x 4.9. 6, Part of cross section of stem, x 127. 7, Cells from middle of leaf, x 95. 8, Lobe from mouth of perianth, x 127. 9, Shoot, dorsal view, x 4.9. 10, Cells from median base of leaf, x 293. 11, Five gemmae, x 254. 12, Shoot with perianth, dorsal view, x 5.3. (1, 3, 6, 8, 11, after Buch; 2, 4-5, 7, 9. 12, after Evans; 10, original.)

Diplophyllum plicatum from Frye & Clark 1946 p. 573.

Distinctive characters:
The well developed vitta, nodose trigones, and decurrent wings characterize this species.

Similar species: The common *Diplophyllum albicans* also has a vitta in its leaf lobes, but in *Diplophyllum plicatum* the vitta is inconspicuous under the hand lens and evident only under a microscope. *Diplophyllum albicans* does not have nodose trigones.

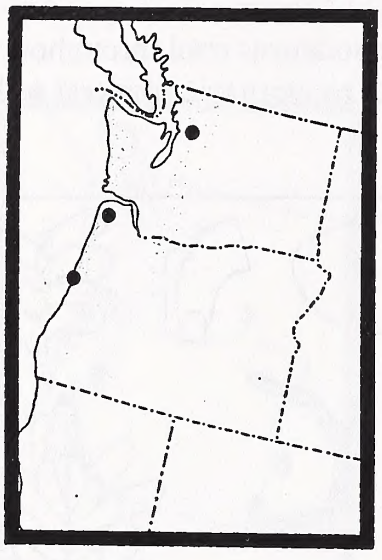


Diplophyllum plicatum leaf.

Other descriptions and illustrations: Frye & Clark

1946: p. 573 (*573*).

Conservation Issues: The southernmost records of this species are sporadic and ecologically unrelated. At this point we know it from the northern Oregon Coast Sitka spruce zone and on Saddle Mountain in Clatsop County. It may occur in any similar suboceanic habitat, either on organic (bark) or inorganic (rock) substrate. It is somewhat more abundant in Washington. Additional information about the species is needed.



DOUINIA OVATA (Dicks.) Buch
Sharp-tip foldedleaf
Recent synonyms: none.

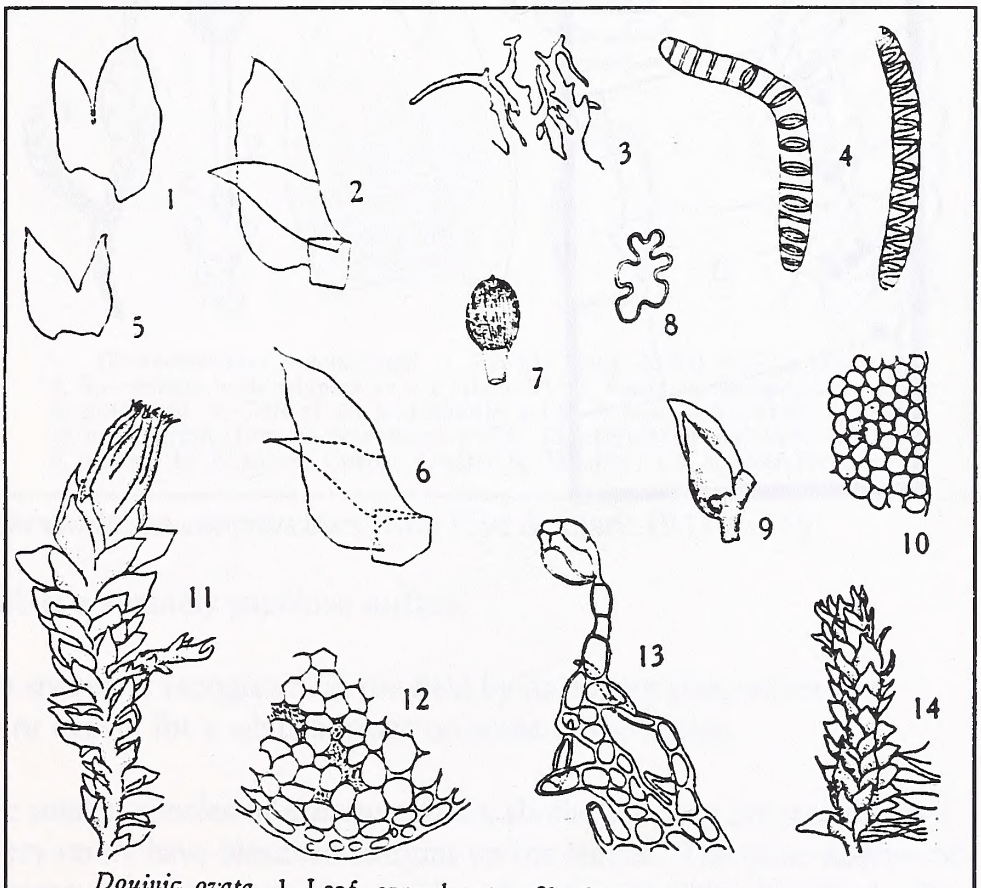
Status: ROD Table C-3; Final SEIS Table J2-8a.

Distribution: Widespread in western North America; less common in southern Oregon and California; Europe.

Habitat/Ecology: On tree trunks and large branches; wet rocks. It appears to be a typical element of the bryophyte community in old-growth forests. A tree-climbing bryologist, S. Sillett, reports (pers. comm.) that this species grows on the underside of large, exposed branches of *Pseudotsuga menziesii* whereas the moss *Antitrichia curtipendula* forms deep mats on the upper side of the branches. *Douinia ovata* also is frequent on the lower trunks of these trees where light levels are high. This species has a second distinctive habitat, on exposed rocks on fog-drenched ridges. Here it has a low correlation with any particular vascular plant community but is more closely tied to microsite characteristics.

Description: Medium sized, dull green plants, often with a dusty grayish cast. Shoots semi-erect or sprawling, turned up at the tip. Leaves deeply bilobed, the lobes folded over. Upper lobe shorter than the lower lobe. Lobes gradually tapering to a sharp point, the margins entire. Perianths common, these having longitudinal folds and narrowing to the mouth. Perianth tips are often bleached white, so that a patch with many perianths will appear white dotted at arm's length.

Distinctive characters: The sharp points on the entire lobes, the dull, almost dusty appearance of the leaf surfaces, and white-tipped perianths are



Douinia ovata. 1, Leaf, spread out, x 21. 2, Leaf, dorsal view, x 26. 3, Part of mouth of perianth, x 53. 4, Two elaters, x 222. 5, Leaf, spread out, x 21. 6, Leaf, ventral view, x 26. 7, Sporangium, x about 9. 8, Cross section of perianth, x 21. 9, Male bract, dorsal view, x about 16. 10, Cells along leaf margin, x 185. 11, Shoot with perianth, dorsal view, x 9. 12, Part of cross section of stem, x 188. 13, Branched cilia of mouth of perianth, x 188. 14, Male shoot, dorsal view, x 9. (1, 3-5, 8, 10-11, 14, after K. Mueller; 2, 6, 12-13, after Buch; 7, 9, after Hooker.)

Douinia ovata from Frye & Clark 1946 p. 589.

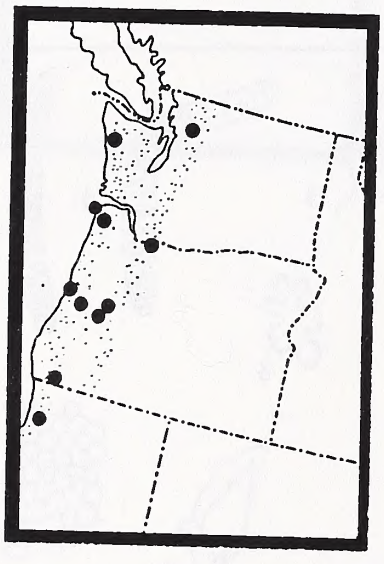
diagnostic.

Similar species: The species of *Diplophyllum* and *Scapania*, which also have bilobed, folded leaves, all differ from *Douinia* in having mostly rounded to obtuse lobe tips, never tapering to a sharp point. The species of *Scapania* with lobe tips somewhat acute have dentate, not entire margins. The leaves of *Diplophyllum* and *Scapania* are usually more shiny than *Douinia*.

Other descriptions and illustrations: Frye & Clark 1946: p. 588, *589*. Müller 1957: p. 904, fig. 321. Smith 1990: p. 167, fig. 69.

Notes/Comments: The abundance of this species in the canopy of old-growth trees seems to increase with a stand age greater than 300 years.

Conservation Issues: The system of old-growth reserves established by the President's Plan is likely to maintain viable populations of this species, and the cryptogamic community with which it is associated.



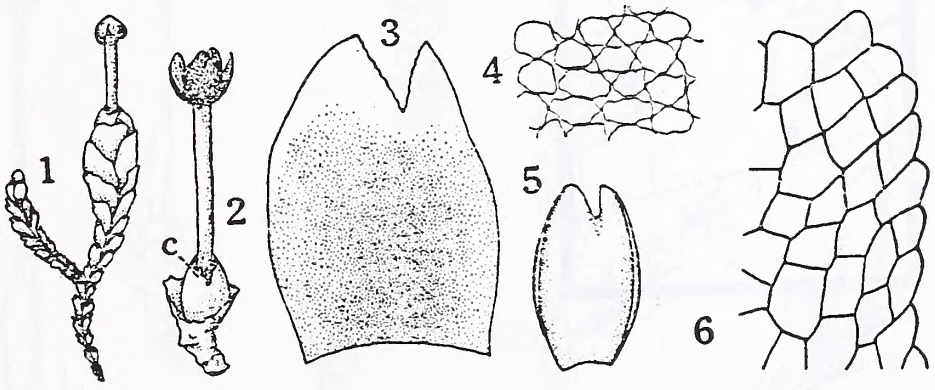
GYMNOMITRION CONCINNATUM (Lightf.) Corda
Pointy whiteworm
Recent synonyms: none.

Status: ONHP List 3.

Distribution: Circumboreal, in both eastern and western North America. Known in Oregon from Larch Mountain and Mt. Hood, Multnomah County. In Washington reported from Mt. Baker and the Olympic Peninsula.

Habitat/Ecology: On peaty soil in open subalpine areas, often associated with cliffs and rock outcrops. As yet there is no clear pattern of plant associates, either bryophyte or vascular plant. It appears that the microsites where this species occurs are colonized randomly by individuals from a suite of species with similar habitat requirements.

Description: Minute, yellowish-brown to dull greenish-white plants growing in dense patches. The worm-like shoots have two rows of cupped leaves that overlap tightly, so that individual leaves are difficult to detach for microscopic examination. Leaves are shallowly bilobed, the lobe tips sharply acute. When viewed under high magnification, the cuticle exhibits a minutely papillose surface.



Gymnomitrium concinnatum. 1, Female plant, dorsal view, x about 11. 2, Sporophyte with calyptra (*c*), x about 21. 3, Leaf, the unshaded portion hyaline, x 40. 4, Cells of the leaf middle, x 197. 5, Leaf, x about 23. 6, Cells of leaf margin from tip downward, x 321. (3, original by Helen M. Gilkey; 6, original by Elizabeth Curtis; 4, after K. Mueller; 1-2, 5, after Hooker.)

Gymnomitrion concinnatum from Frye & Clark 1943 p. 215.

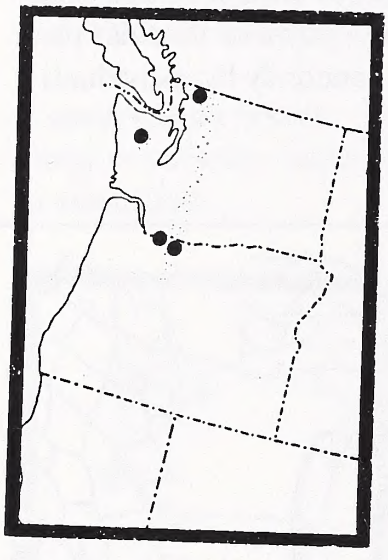
Distinctive characters: This species is recognized in the field by its minute size, worm-like shoots, and pale brownish color except for a whitish fringe on some of the leaves.

Similar species: Some of the smaller species of *Marsupella* are similar but they are usually very dark brown to blackish and very rarely have bleached margins on the leaves. The other species of *Gymnomitrion* are pure pale green and have a bettered developed margin of white, bleached cells around the tips of the leaves, and either have a smooth cuticle or rounded lobe tips.

Other descriptions and illustrations: Frye & Clark 1943: p. 214, *215*. Müller 1957: p. 796, figs. 268, 269. Schuster 1974: p. 135, fig. 328. Smith 1990: p. 164, fig. 68.

Notes/Comments: There is some question whether the collection from Larch Mountain was correctly identified. The list of species in the report containing this record do not mention *Gymnomitrion obtusum*, the common species of this genus on Larch Mountain. It would be good to relocate and reconfirm the presence of *G. concinnatum* at this locality.

Conservation Issues: This species has been observed so rarely that little can be said about its distributional stability. The sites where it known indicate an affinity for mountainous areas that are still poorly explored, so that its frequency and abundance across the landscape are not easily assessed.



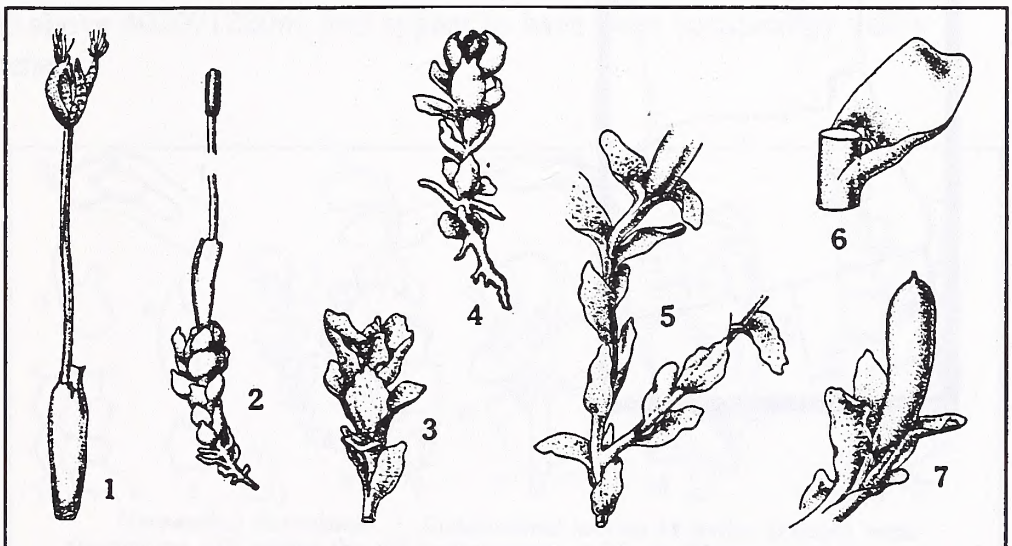
HAPLOMITRIUM HOOKERI (Smith) Nees
Ancestorwort
Recent synonyms: none.

Status: ONHP List 3.

Distribution: Circumboreal, in the Pacific Northwest south to Mt. Baker region, Washington, and the Three Sisters Wilderness, Oregon.

Habitat/Ecology: Along rivulets or on heather slopes in subalpine-alpine situations. Rarely in pure patches but growing mixed in with other bryophytes. In the Three Sisters Wilderness it was growing among *Lophozia opacifolia* and *Moerckia blyttii*. Because it was identified in the laboratory, habitat characteristics were not recorded.

Description: Pale green, small to medium-sized shoots that look remarkably like a soft, lax *Bryum*. The leaves are in three distinct rows, irregularly rhombic in shape. Microscopic examination of fresh, living material will reveal numerous oil-bodies in each cell, clear and about half the size of the chloroplasts. *Haplomitrium* produces a fleshy, tubular calyptra instead of a perianth like most of the leafy liverworts. The shoots often have a network of leafless stems growing down through the moss mat it inhabits.



Haplomitrium hookeri. 1, Perianth and open sporangium, x about 4. 2, Plant with sporophyte, x 2.6. 3, Upper portion of male plant with antheridia, x about 5. 4, Male plant with antheridia at tip barely visible, x 5.3. 5, Portion of female plant, x about 5. 6, Male bract with antheridia, x about 21. 7, Tip of female plant with calyptra, x about 8. (1, 3, 6, 7, after Hooker; 2, 4, after K. Mueller; 5, after Pearson.)

Haplomitrium hookeri from Frye & Clark 1943 p. 172.

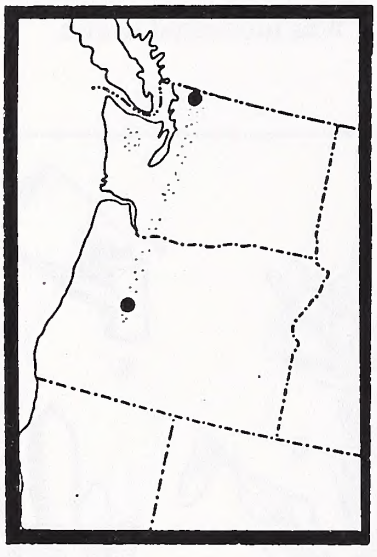
Distinctive characters: The rounded-rhombic, soft leaves lacking a midrib, growing in three vertical rows on the stem are distinctive.

Similar species: No other liverwort looks like this; it is more likely to be mistaken for a moss.

Other descriptions and illustrations: Frye & Clark 1943: p. 171, *172*. Müller 1954: p. 550, fig. 157. Schuster 1966: p. 638, figs. 68, 69. Smith 1990: p. 10, fig. 2. Worley 1969.

Notes/Comments: According to Schuster (1966, p. 641), "The chief problem with *Haplomitrium* is not to identify it but to be able to locate it. It is a difficult plant to find in the field." This seems to be true in Oregon, as well. Worley (1969) is one of the few who report field experience, having located large populations *in situ*.

Conservation Issues: See comments in previous treatment. There is potential damage to the population in the Three Sisters Wilderness from recreational use. Especially dangerous to the streamside habitat of *Haplomitrium* is trampling by horses. It has been observed that where horse traffic has been directed away from previously damaged areas, stream banks appear to be recovering a stable vegetation cover which includes a healthy bryophyte component.



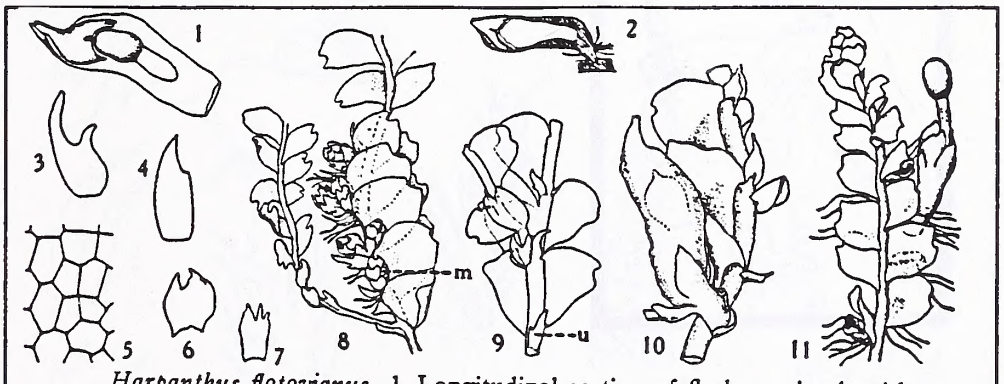
HARPANTHUS FLOTOVIANUS (Nees) Nees
Brown fenwort
Recent synonyms: none.

Status: ONHP List 3.

Distribution: Northern Europe and northern North America, south in the Pacific Northwest to Seven-mile Marsh, Klamath County, Oregon.

Habitat/Ecology: Strongly associated with wet places, often with *Sphagnum*, along streams or in fens where bryophytes are prominent elements of the vegetation. The Klamath County site is a complex of rich fens dominated by *Carex*, and carrs, the dominant shrubs being *Salix* and *Vaccinium*. Here *Harpanthus* grows in protected places where a liverwort-rich bryophyte mat carpets shady banks along the ecotone between wetland and forest. Most of the sites where it has been found are at elevations above 4000'/1220m, and appear to have been occupied by valley glaciers during the Pleistocene.

Description: Medium to large, sprawling shoots growing in dense mats or mixed in with other bryophytes. Its color is dark green with a yellowish-brown tinge to pale brown. Leaves are very obliquely inserted and spreading widely. The leaves are notched at the apex, the lobe tips most often rounded. Underleaves are two thirds as long as the lateral leaves, narrowly lanceolate, conspicuous even in dried specimens. Gemmae are lacking.



Harpanthus flotovianus. 1, Longitudinal section of fleshy perianth with sporophyte still within the old archegonium, x 7.2. 2, Diagrammatic longitudinal section of female branch and perianth, x about 4.5. 3-4, Underleaves, x 19.1. 5, Leaf cells, x 123. 6-7, Female bracts, x 7.2. 8, Part of plant with ventral branch and six male inflorescences (*m*), x 6.4. 9, Piece of stem with underleaves (*u*), and ventral branching, x 7.2. 10, Part of plant with short ventral female branch, x 7.2. 11, Shoot with female branch, dorsal view, x 6.4. (1, 3-7, 10, after Pearson; 2, 8, 11, after K. Mueller; 9, after Evans.)

Harpanthus flotovianus from Frye & Clark 1945 p. 461.

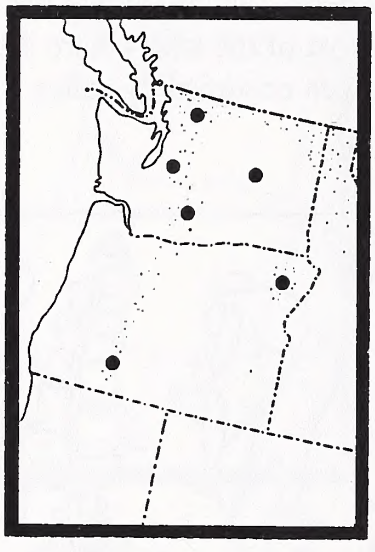
Distinctive characters: The rather large, shallowly bilobed, spreading leaves; the color; and the underleaves all serve to distinguish this species.

Similar species: Could be mistaken for *Gymnocolea graveolens*, *Chiloscyphus pallescens* or a large *Lophozia*, but the large, lanceolate underleaves of *Harpanthus flotovianus* will separate it from the others. *Chiloscyphus pallescens* has ciliate, bilobed underleaves; *Gymnocolea* has simply bifid underleaves; and the similar *Lophozia* species have underleaves which are small and bifid or lacking altogether.

Other descriptions and illustrations: Frye & Clark 1945: p. 460, *461*. Hong 1993. Müller 1957: p. 1064, fig. 398. Schuster 1980: p. 303, fig. 542. Smith 1990: p. 215, fig. 92.

Notes/Comments: Hong (1993) maps four sites in Washington without citation of specimens or locality data. They are replicated in the map below.

Conservation Issues: The upland habitats are likely to suffer mainly from recreation (see comments under *Haplomitrium hookeri*) and grazing. Many of the large fens such as those that harbor this species are open to grazing allotments. Field observations show that bryophytes are particularly sensitive to trampling. The parts of fens where *Harpanthus flotovianus* grows, however, seem to be away from where trampling is greatest.



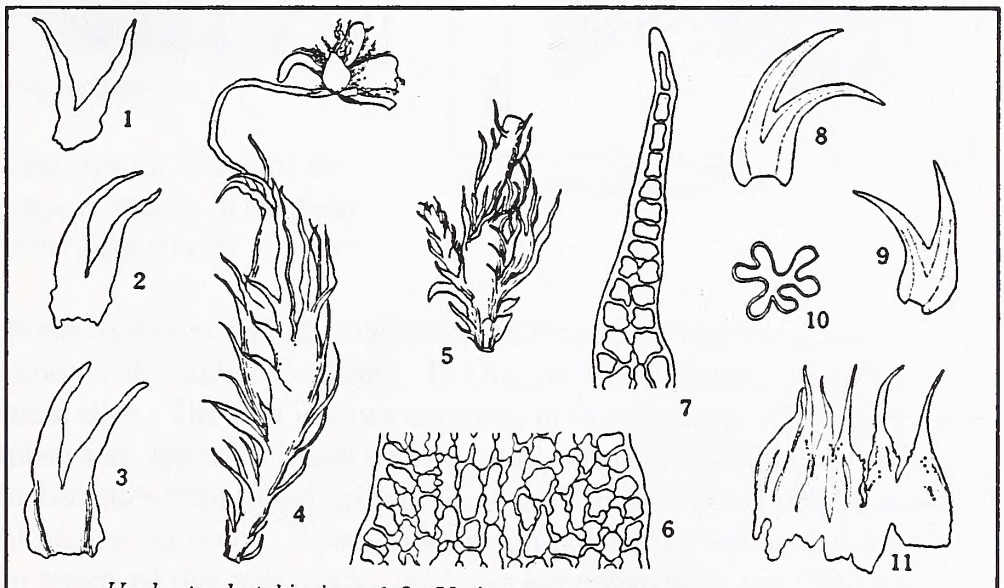
HERBERTUS ADUNCUS (Dicks.) S.F. Gray
Common scissorleaf
Recent synonyms: *H. hutchinsiae* (Gott.) Evans (misapplied).

Status: ONHP List 3; ROD Table C-3.

Distribution: The species is circumboreal; the typical subspecies, as found in the Pacific Northwest, is abundant in British Columbia, rare in Washington, and very scarce in Oregon, where it is presently known from fewer than three localities.

Habitat/Ecology: On a wide variety of substrates, from rocks to tree trunks, from low to high elevations where moisture levels are high and temperatures moderate throughout the year. Recognition of habitat patterns not clear at the southern end of the range. Along the coast of the Olympic Peninsula it seems to be frequent on shore pines, *Pinus contorta*. In Oregon and the Cascades of Washington (where it is not common) it is mainly found on exposed rocks that are wet much of the year.

Description: Small, golden-green to golden brown strands, usually in compact tufts. Except for color, it looks like a moss. Leaves are in three nearly equal rows, deeply divided into two slender lobes. The tapering, pointed leaf lobes all tend to curve downwards, to one side of the stem.



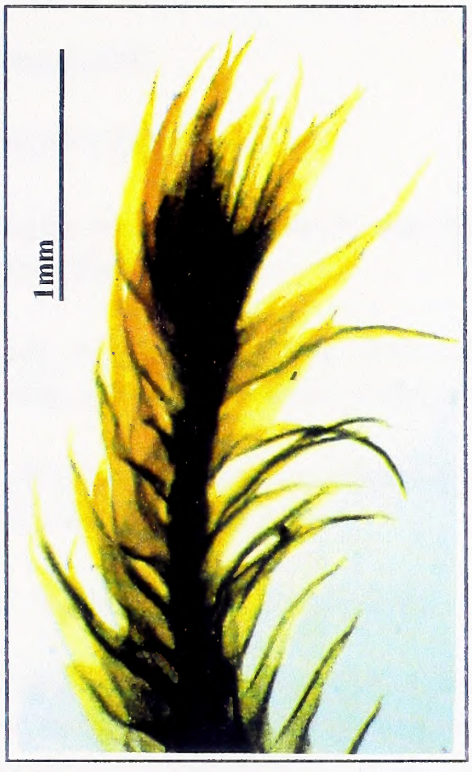
Herberta hutchinsiae. 1-2, Underleaves, x 12.6. 3, Leaves, x 15. 4, Sporophyte on tip of plant, x 5.3. 5, Branch and rejuvenation, x 5.3. 6, Leaf cells, the vaguely vein-like region as longer cells in the middle, x 104. 7, Cells of leaf tip, x 110. 8-9, Leaves, the dotted lines outlining the vein-like region, x 17. 10, Transverse section of perianth, x 17. 11, Perianth, spread out flat, x 11.6. (8-11, after Evans; 1-7, original, by Elizabeth Curtis.)

Herbertus aduncus (probably) from Frye & Clark 1943: 178.

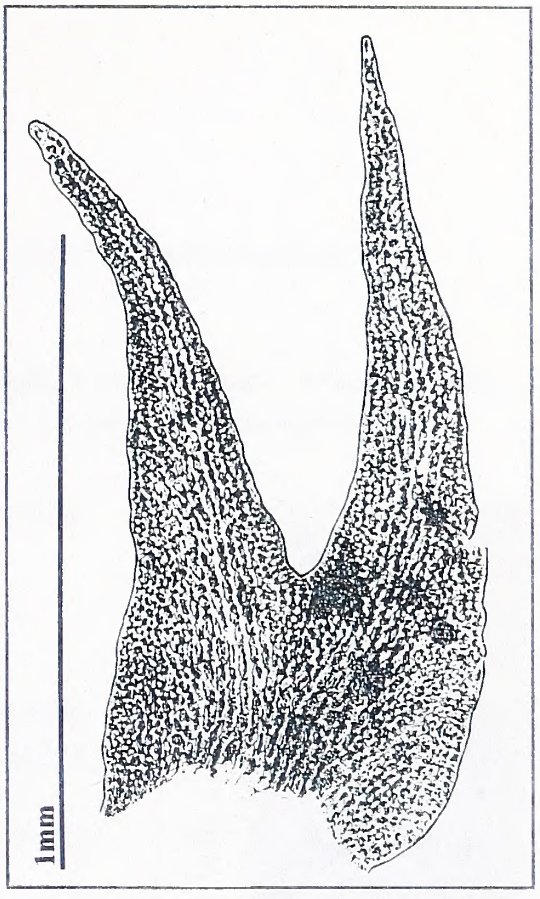
Distinctive characters: The golden-brown, medium size strands stand out in the field. The three rows of deeply forked leaves and size are diagnostic.

Similar species: Looks more like a small, pleurocarpous moss than anything else. Once recognized as a liverwort, it is not likely to be mistaken for any other genus. This species differs from the other species found in our area, *Herbertus sakuraii*, in having slightly more deeply lobed leaves, leaves hardly widened at base, and underleaves more nearly equal to the lateral leaves.

Other descriptions and illustrations: Frye & Clark 1943: p. 177, *178*. Godfrey 1977, p. 64. Pojar & MacKinnon 1994: p. 438. Schuster 1966: p. 712, figs. 71-71 (subsp. *tenuis*). Smith 1990: p. 16, fig. 3.



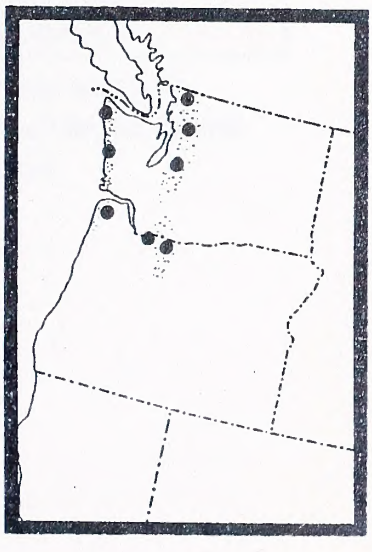
Herbertus aduncus



Herbertus aduncus leaf.

Notes/Comments: The leaves are so closely overlapping that individual details are difficult to discern with a hand lens. However, a botanist with a clear mental image of the plant should be able to recognize it readily in the field. See also comments under *Herbertus sakuraii*.

Conservation Issues: *Herbertus aduncus* and *Herbertus sakuraii* can be treated together because they are so close taxonomically and ecologically. In Oregon these are very rare and reported only from arctic- boreal sites. The first is more common in Washington. They tolerate both inorganic and organic substrates, typically found on wet, shady cliffs and the bark of trees. They are more tied to undisturbed sites than to old growth forests. The sites which might cause concern are the seepy cliffs of natural outcrops. Road-building appears to provide extensive rocky habitats, but it has been observed that wet, rocky roadcuts are primarily covered with common, pioneer species. Of course, eventually the rarer species might move in, but no study has been done to estimate how long that might be. My current view is that the mosses, lichens, and liverworts on undisturbed rock outcrops represent old growth cryptogam communities. Lichenometry at alpine sites indicates that the cryptogam communities may be millennia old. Planning to conserve cryptogam diversity should address the conservation of natural outcrops. Such outcrops are favored habitats of many restricted vascular plants as well as cryptogams, so that studies are likely to be quite productive if they integrate cryptogams with the vascular plants.



HERBERTUS SAKURAII (Warnst.) Hatt.
Pacific scissorleaf
Recent synonyms: none applicable.

Status: ONHP List 3; ROD Table C-3.

Distribution: North Pacific; extending down on west coast of North America to Saddle Mountain, Clatsop County, Oregon.

Habitat/Ecology: Usually on peaty substrates, where constantly cool and moist. It is unknown if these sites are consistently correlated with any vascular plant species or vegetation types.

Description: Plants small to medium sized, golden-brown strands. See *Herbertus aduncus* for further description.

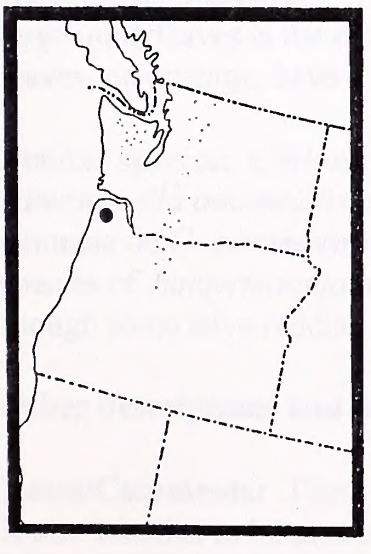
Distinctive characters: Same as *Herbertus aduncus*.

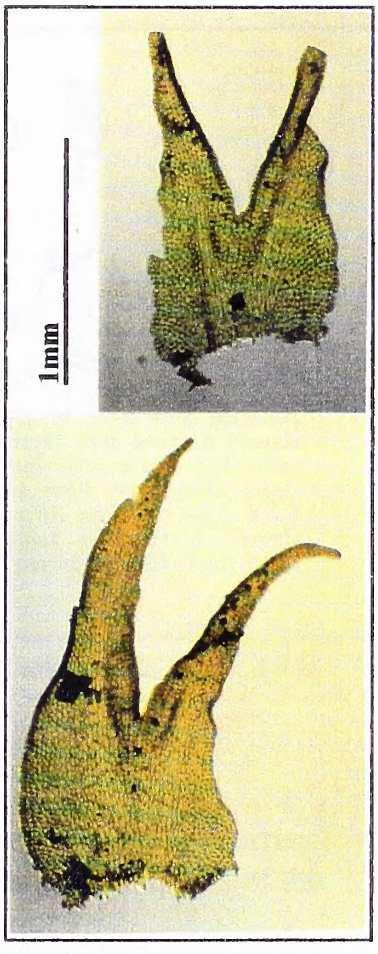
Similar species: To be distinguished only from the more common *Herbertus aduncus*. This differs in being slightly larger on average, with leaf bases being broader and more rounded at the corners. Also, its underleaves are more differentiated from lateral leaves than in *Herbertus aduncus*.

Other descriptions and illustrations: Godfrey 1977, p. 64.

Notes/Comments: *Herbertus* has a rather convoluted taxonomic literature (see, for example, Schuster 1966, pp. 716-718).

Conservation Issues: The only known site for this species in Oregon and Washington is in an Oregon State Park where the species seems adequately protected. The chief danger would be local disturbance from recreation-related activities.





Herbertus sakuraii, underleaf above, lateral leaf below

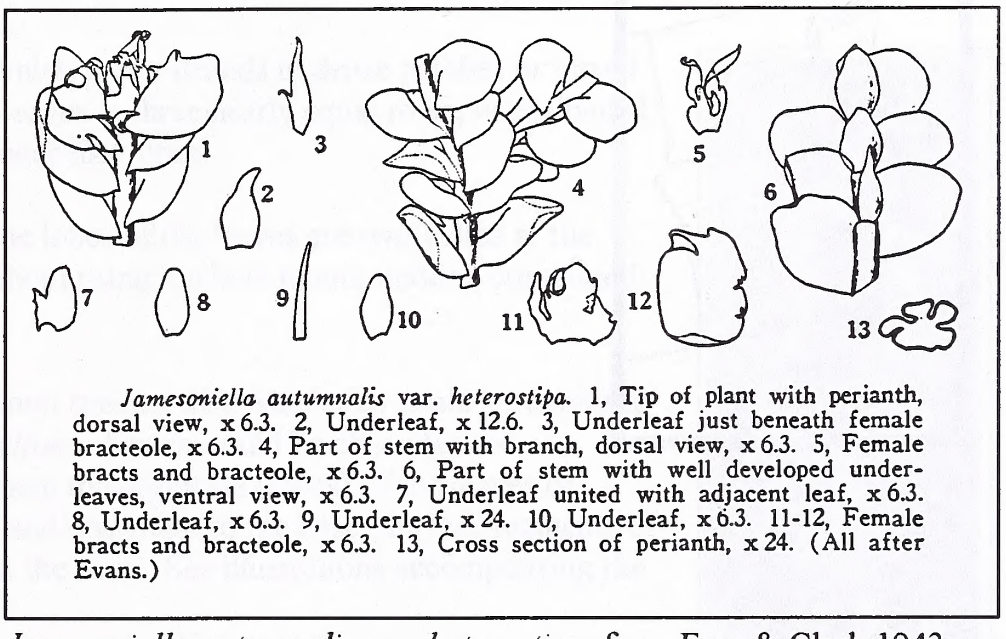
JAMESONIELLA AUTUMNALIS var. HETEROSTIPA (Evans) Frye & Clark
Waldo Lake liverwort
Recent synonyms: none.

Status: ONHP List 3.

Distribution: Known from only four sites in the world; two in eastern Canada, one in British Columbia, and one in Waldo Lake, Lane County, Willamette National Forest, Oregon.

Habitat/Ecology: Apparently an obligate aquatic; on stones in moving water or in deep, ultra-oligotrophic lakes.

Description: Medium to small liverworts with round, succubous leaves. Dark green, often with reddish pigmentation. Rhizoids reddish. Forming loose mats in deep water, where stems may be in excess of 5 cm. Deep water forms have very small, remote leaves and are morphologically identifiable only on the basis of comparison of a graduated series of specimens from deep to shallow water.



Jamesoniella autumnalis var. *heterostipa*. 1, Tip of plant with perianth, dorsal view, x 6.3. 2, Underleaf, x 12.6. 3, Underleaf just beneath female bracteole, x 6.3. 4, Part of stem with branch, dorsal view, x 6.3. 5, Female bracts and bracteole, x 6.3. 6, Part of stem with well developed underleaves, ventral view, x 6.3. 7, Underleaf united with adjacent leaf, x 6.3. 8, Underleaf, x 6.3. 9, Underleaf, x 24. 10, Underleaf, x 6.3. 11-12, Female bracts and bracteole, x 6.3. 13, Cross section of perianth, x 24. (All after Evans.)

Jamesoniella autumnalis var. *heterostipa* from Frye & Clark 1943: 274.

Distinctive characters: From other submerged aquatics, the regular, but sporadic, occurrence of large underleaves is the most obvious character that distinguishes this plant. About 5 % of the leaves, on average, have a truncate or retuse tip.

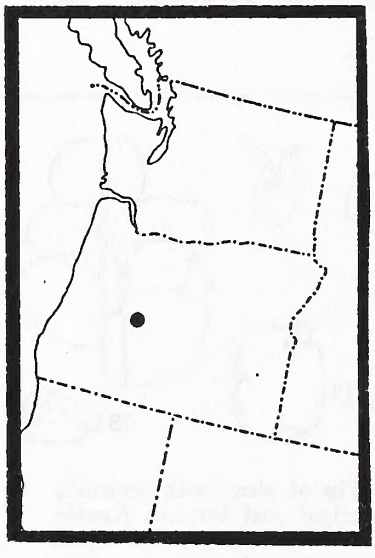
Similar species: *Chiloscyphus gemmiparus* shares all of the general characteristics of *Jamesoniella autumnalis heterostipa*, including the sporadic giant underleaves. The presence of gemmae on *C. gemmiparus*, isophylly of fertile shoots, and habitat will distinguish it. The aquatic species of *Jungermannia* have uniformly round-tipped leaves and lack underleaves altogether, though some have reddish pigmentation.

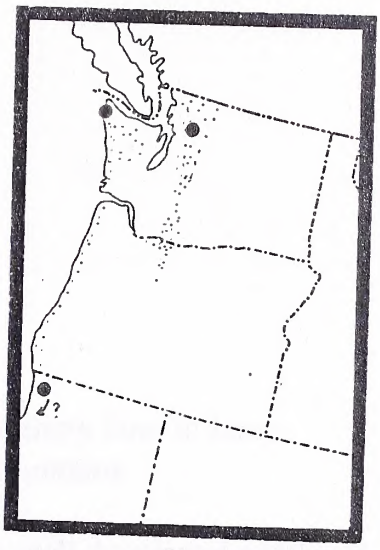
Other descriptions and illustrations: Frye & Clark 1943: 274, *274*. Evans 1915, plate I.

Notes/Comments: There are some unresolved taxonomic issues regarding the use of this name. It also remains to be proven, perhaps by molecular techniques, that the plants at the bottom of

Waldo Lake, 127m/416' deep (Maleug et al. 1972), much reduced in size (depauperate), are the same as plants studied at 5m deep. Identification was based on 5m deep specimens.

Conservation Issues: Whatever the liverwort that grows at the bottom of Waldo Lake is called, it is certainly an unusual plant. There is no deeper place, in any other lake in the world, where liverworts are found "growing luxuriously" (Maleug et al. 1972). Only in Lake Tahoe was a plant, a moss, found growing at greater depth. So long as the water in Waldo Lake remains purer than distilled water, the liverwort at the bottom should persist indefinitely.





KURZIA MAKINOANA (Steph.) Grolle
Slender clawleaf
Recent synonym: none.

Status: ROD Table C-3; Final SEIS Table J2-8a.

Distribution: Around the northern Pacific, Asia to California. One record in California, not yet found in Oregon, rare in Washington.

Habitat/Ecology: There is little documentation about the habitat of this species in the region covered here. In SE Alaska it grows in boggy sites associated with *Sphagnum* but this association does not persist in the south. It seems to prefer shady, moist organic substrates.

Description: Minute, brownish-green strands in dense patches or mixed in with other bryophytes. Leaves in three nearly equal rows, each divided into three or usually four finger-like lobes.

Kurzia makinoana

Distinctive characters: The lobes of the leaves are two-celled at the base. Impossible to see without using a whole mount under a compound microscope.

Similar species: The common species with which this could be confused is *Blepharostoma trichophyllum*. *Kurzia* could be characterized as a stubby *Blepharostoma*. Where the segments (lobes) of the leaves of *Blepharostoma* are narrow and uniseriate to the base, the leaf segments of *Kurzia* are two cells wide at the base. See illustrations accompanying the generic keys.

Other descriptions and illustrations: Hattori & Mizutani 1958. Hong 1988. Inuoe 1974, p. 177, pl. 15. Schuster 1980a.

Notes/Comments: A discussion of the taxonomic status of this species has been prepared by Schuster (1980), wherein he argues strongly for the recognition of *K. makinoana* as a distinct species in a restricted sense. The taxonomic problems are not especially pertinent to botanists in the Pacific Northwest, since they relate mainly to plants of Europe. Even in a broad sense, *K. makinoana* is the name we would use for our plants. Schofield (pers. comm.) believes that one of the segregate species, *K. sylvatica*, may occur in British Columbia. Hong (1988) uses this name instead of *K. makinoana*. Regardless of the name used, the status is the same: the plant is extremely rare.

Conservation Issues: This is a species so rare that little is known about its biology or habitat requirements.

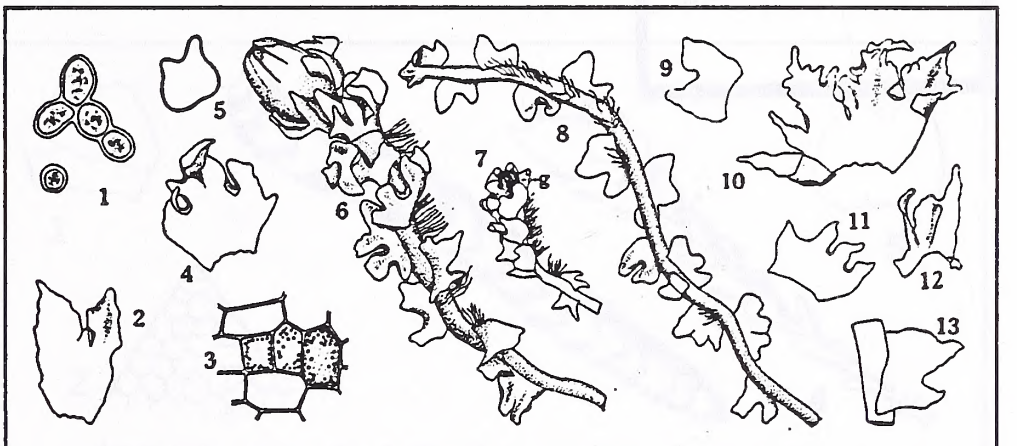
LOPHOZIA LAXA (Lindb.) Grolle
bog palewort
Recent synonym: *Lophozia marchica* (Nees) Steph.

Status: ONHP List 2.

Distribution: Circumboreal; in western North America it reaches a southern limit in Lane County, Oregon. It occurs in both coastal areas and in the Cascade Mountains.

Habitat/Ecology: Growing among and over branches of *Sphagnum* in well-developed peatlands. In the Cascades it grows with *Vaccinium occidentale, Tofieldia, Drosera, Carex, Aulacomnium,* and *Cephaloziella.*

Description: Medium sized, pale green shoots sprawling among the heads of *Sphagnum.* Leaves variable, 2- or occasionally 3-lobed, margins wavy, inserted obliquely and usually rather widely spaced along the stem. Underleaves lacking; gemmae abundant. Oil-bodies numerous, small, clear.



Lophozia marchica. 1, A single gemma and a group of four, x 381. 2, Female bracteole, x 9.3. 3, Leaf cells, x 127. 4, Leaf immediately below female bract, x 9.3. 5, Cross section of perianth in upper fourth, x 9.3. 6, Shoot with perianth, dorsal view, x 7.6. 7, Shoot with gemmae (*g*), x 5.3. 8, Sterile shoot, ventral view, x 7.6. 9, Leaf from basal region of shoot, x 10.6. 10, Female bract, x 9.3. 11, Leaves from upper part of shoot, x 10.6. 12, Underleaf immediately below the female bracteole, x 9.3. 13, Leaf of sterile stem, attached, dorsal view, x 30. (1, 3, 9, 11, after Warnstorf; 2, 4-6, 8, 10, 12, after Evans; 7, after Jensen; 13, after Haynes.)

Lophozia laxa from Frye & Clark 1945:356.

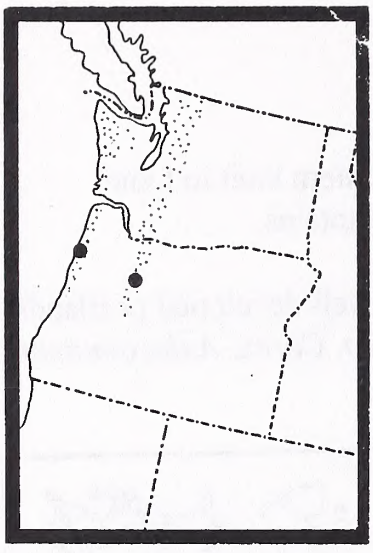
Distinctive characters: The underside of the stem, often the leaf bases, and the rhizoids are deep purple-red while the rest of the plant is pale, translucent green. These features coupled with the habitat serve to distinguish the species.

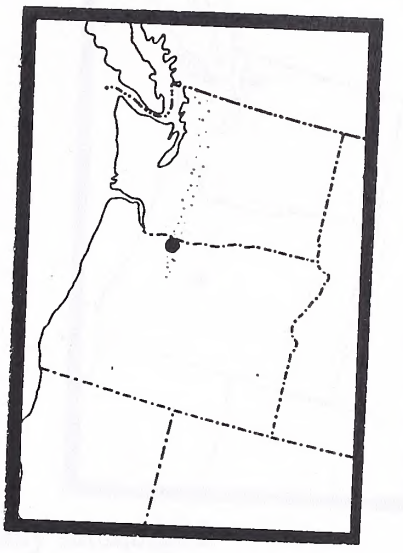
Similar species: *Fossombronia foveolata* has bright red rhizoids and wavy leaf margins, but the underside of the stem is not red-pigmented and it does not grow on *Sphagnum.* The other species of *Lophozia* subgenus *Massula* have similar oil-bodies but also possess underleaves.

Other descriptions and illustrations: Frye & Clark 1945: 355, *356.* Müller 1954: 675, fig. 208. Schuster 1953: 347, pl. 13. Schuster 1969: 464, fig. 185.

Notes/Comments: This species appears to be restricted to sites where *Sphagnum* produces well-developed peat mounds, not every site where *Sphagnum* occurs.

Conservation Issues: see comments under *Calypogeia sphagnicola*.





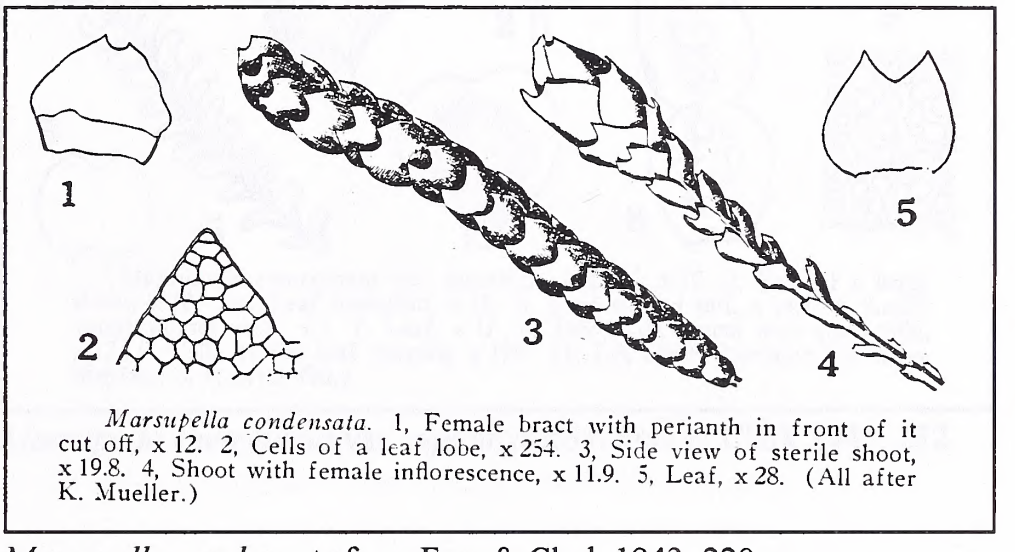
MARSUPELLA CONDENSATA (Ångstr.) Schiffn.
alpine ladderwort
Recent synonyms: none, but authority citation varies in different references.

Status: ONHP List 3.

Distribution: Circumboreal. British Columbia, Canada. Mt. Hood, Oregon.

Habitat/Ecology: Arctic-alpine, on peaty soil in relatively exposed sites, where probably moist throughout the year. The Mt. Hood site was on a heather slope. However, it is likely to be more closely associated with microsite conditions rather than a particular vascular plant community.

Description: Minute plants with transversely inserted, shallowly bilobed leaves. Oil-bodies granular, 2-3(4) per cell. Dioecious.



Marsupella condensata. 1, Female bract with perianth in front of it cut off, x 12. 2, Cells of a leaf lobe, x 254. 3, Side view of sterile shoot, x 19.8. 4, Shoot with female inflorescence, x 11.9. 5, Leaf, x 28. (All after K. Mueller.)

Marsupella condensata from Frye & Clark 1943: 220.

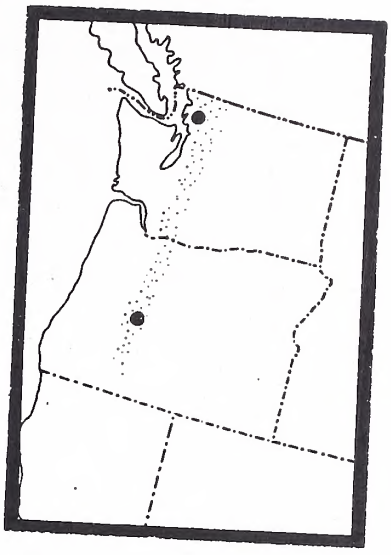
Distinctive characters: Small size; leaves tightly overlapping; dark color; oil-bodies in all cells. "Especially distinctive are the julaceous shoots with red-gold to chestnut-brown secondary pigmentation and leaves with lunate sinus and with oil-bodies in all cells including the marginal cells." (Godfrey & Schofield 1979)

Similar species: Species of *Gymnomitrion* are similar but these have bleached leaf margins which lack chloroplasts and oil-bodies in marginal cells.

Other descriptions and illustrations: Frye & Clark 1943: 220, *220*. Hong 1982. Godfrey & Schofield 1979. Müller 1957: 793, fig. 266. Schuster 1974, p. 109. Smith 1990: 161, fig. 66.

Notes/Comments: This is one of the plants whose small size probably contributes to apparent rarity. Strands mixed in with other bryophytes would be easily overlooked.

Conservation Issues: Only careful, extensive surveys of suitable habitats will determine the true extent of this species, as well as its habitat preferences. See also the comments under *Anastrophyllum minutum*.



MARSUPELLA EMARGINATA var. AQUATICA (Lindenb.) Dum.
stream ladderwort
Recent synonym: *Marsupella aquatica* (Lindenb.) Schiffn.

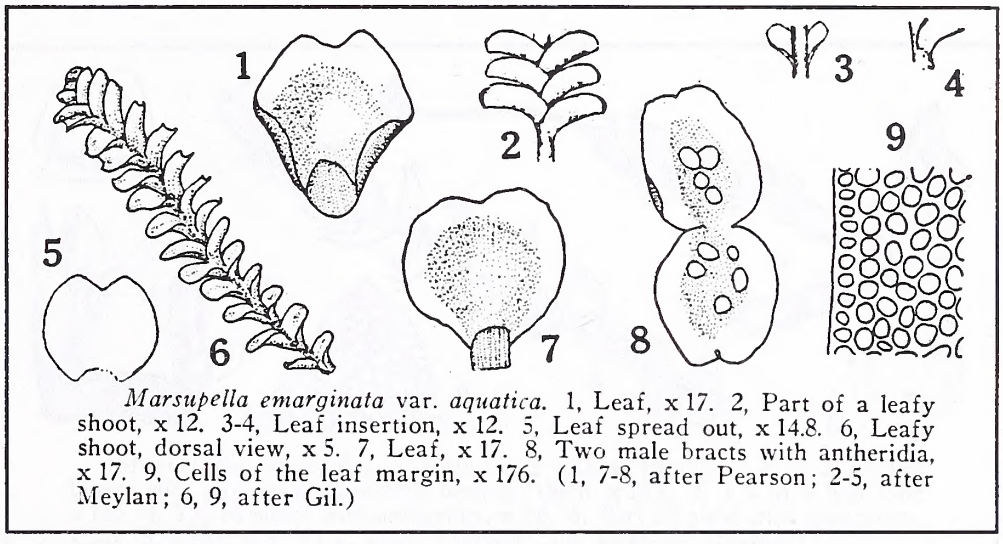
Status: ONHP List 3; ROD Table C-3; Final SEIS Table J2-8a.

Distribution: Circumboreal. In the PNW known only from outlet stream of Waldo Lake, Lane County, Oregon.

Habitat/Ecology: Attached to rocks in montane streams where perennially submerged.

Description: Medium sized, dark green plant with transversely inserted, bilobed leaves. Mostly with 2 oil-bodies per leaf cell. Grows in dense tufts.

Distinctive characters: Stream habitat: restricted to swiftly flowing streams at higher elevations. Stiffly spreading, closely placed, bilobed leaves with revolute margins.



Marsupella emarginata var. *aquatica*. 1, Leaf, x 17. 2, Part of a leafy shoot, x 12. 3-4, Leaf insertion, x 12. 5, Leaf spread out, x 14.8. 6, Leafy shoot, dorsal view, x 5. 7, Leaf, x 17. 8, Two male bracts with antheridia, x 17. 9, Cells of the leaf margin, x 176. (1, 7-8, after Pearson; 2-5, after Meylan; 6, 9, after Gil.)

Marsupella emarginata var. *aquatica* from Frye & Clark 1943: 232.

Similar species: No other aquatic bryophyte is similar. It is very much like the normal, terrestrial form of *Marsupella emarginata* (var. *emarginata*) except the leaves are much more stiffly spreading and the margins more tightly rolled under. Although the terrestrial form grows on rocks in very wet places, as on stream canyon walls, it is never in places submerged throughout the year.

Other descriptions and illustrations: Frye & Clark 1943: 231, *232*. Hong 1982. Müller 1957: 774, fig. 255. Schuster 1974, p. 82. Smith 1990: 156, fig. 64.

Notes/Comments: At least some contemporary authorities recognize this taxon at the species level. The author is inclined to accept this view.

Conservation Issues: This aquatic is known (in western North America) only from one site on the Willamette National Forest. It grows attached to rocks in the cold, perennial outlet streams of Waldo Lake. The site is shaded by large mountain hemlock but receives partial sun. The cryptogamic flora of cold mountain streams is relatively rich; the ecological reasons for this remain poorly known. Long term habitat stability seems likely to be an important factor.

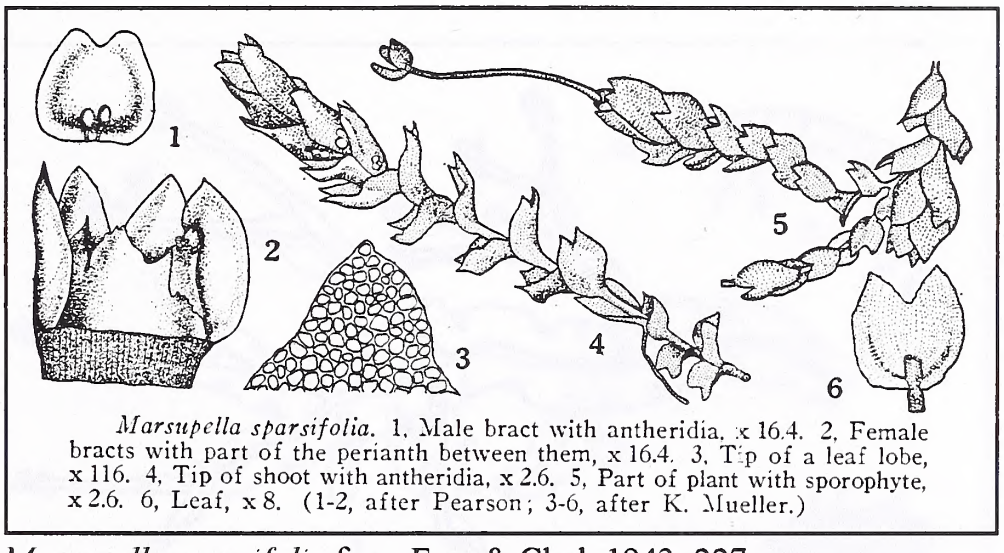
MARSUPELLA SPARSIFOLIA (Lindb.) Dum.
sharp ladderwort
Recent synonyms: none.

Status: ONHP List 3.

Distribution: Northern Europe to northern North America, also in the southern hemisphere. British Columbia, Canada. Washington (Hong 1982). Mt. Hood, Oregon. California (Hong 1982).

Habitat/Ecology: Poorly characterized; on Mt. Hood it is recorded from wet soil.

Description: Small reddish-brown to blackish plants growing in dense mats. Leaves in two rows, crowded, spreading, transversely inserted, bilobed. Leaf margins not recurved. Fertile shoots bisexual (paroecious). Perianth shorter than inner bracts.



Marsupella sparsifolia. 1, Male bract with antheridia, x 16.4. 2, Female bracts with part of the perianth between them, x 16.4. 3, Tip of a leaf lobe, x 116. 4, Tip of shoot with antheridia, x 2.6. 5, Part of plant with sporophyte, x 2.6. 6, Leaf, x 8. (1-2, after Pearson; 3-6, after K. Mueller.)

Marsupella sparsifolia from Frye & Clark 1943: 227.

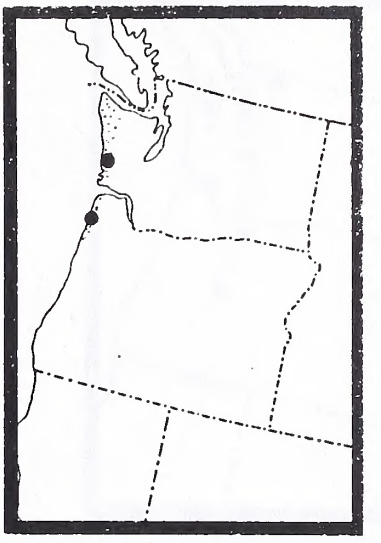
Distinctive characters: The pointed tips of the leaf lobes and paroecious shoots (antheridia are located in the axils of bracts immediately below the archegonial tip) are diagnostic.

Similar species: There are several similar species of *Marsupella*, from which this species is distinguished by its sharply-pointed lobe tips and occurrence on soil instead of rock.

Other descriptions and illustrations: Frye & Clark 1943: 226, *227*. Hong 1982. Müller 1957: 765, fig. 250. Schuster 1974, p. 40, fig. 309. Smith 1990: 159, fig. 65.

Notes/Comments: An arctic-alpine species growing in exposed sites. Determining the sexuality of ladderworts must be done under a dissecting microscope using fine-pointed forceps. By the time capsules are evident, the antheridia will have collapsed and may be difficult to detect. The antheridial stalks usually persist for some time, and the presence of male bracts may be inferred from their basal bulge.

Conservation Issues: Poorly known because of rarity.



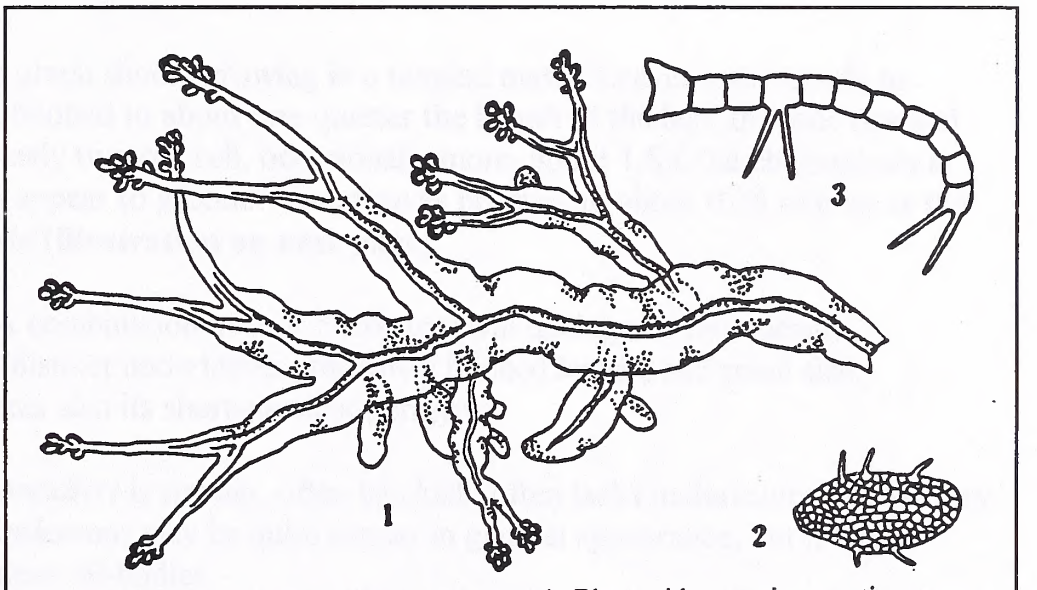
METZGERIA TEMPERATA Kuwah.
nubbly daintyribbons
Recent synonyms: *Metzgeria fruticulosa* (Dicks.) Evans (misapplied name).

Status: ONHP List 3.

Distribution: North Pacific, in North America reported south to Oswald West State Park, Tillamook County, Oregon.

Habitat/Ecology: On tree trunks, usually shaded, near the coast; growing in dense mats or mixed among other bryophytes. In Alaska it has been found on the roots of *Picea sitchensis*.

Description: Small, green, repeatedly forking ribbons up to 1.5 mm wide, often acquiring a bluish tinge when dried. Tiny hairs occur singly along the margins of the thallus. Gemmae abundant on lobe tips.



Metzgeria furcata var. *fruticulosa*. 1, Plant with gemmiparous tips, x about 10. 2, Gemma, x about 13. 3, Cross section of part of thallus, x 140. (1, 2, after Hooker; 3, after Meylan.)

Metzgeria temperata from Frye & Clark 1937: 136.

Distinctive characters: Thin, narrow (<.5 mm wide) green ribbons tapering to gemmae-bearing tips are diagnostic. The gemmae are multicellular, shaped like lentils, ca 0.16 mm in diameter.

Similar species: *Metzgeria conjugata* is very similar and sometimes has gemmae on the thallus margins but it lacks the attenuate branch tips of *M. temperata* and has paired marginal hairs.

Other descriptions and illustrations: Frye & Clark 1937: 136, *136*. Kuwahara, 1976. Schuster 1992, p. 706, fig. 892. Smith 1990: 304, fig. 134.

Notes/Comments: Oregon record (s) remain to be verified. This species has not been reported from the area since 1964.

Conservation Issues: This is a species of northern, boreal affinities. Its survival in the area is likely to be dependent on the health of the cool temperate rainforests.

NARDIA JAPONICA Steph.
Pacific spikewort
Recent synonyms: none.

Status: ONHP List 3.

Distribution: Siberia, coastal North Pacific; fairly common in British Columbia and then rare south through Washington to the north side of Mt. Hood and Broken Top, Three Sisters Wilderness, Deschutes County, Oregon.

Habitat/Ecology: This grows on peaty soil on rocky ledges or in rocky meadows, in subalpine habitats in our region.

Description: Small, olive green shoots growing in a tangled mass. Leaves transversely to slightly obliquely inserted, bilobed to about one-quarter the length of the leaf, the lobe tips and sinus acute. Oil-bodies mostly two per cell, occasionally more, about 1.8X the chloroplasts in size; they are so clear they appear to glisten. Underleaves prominent, about 0.25 as long as the leaves, irregularly lanceolate (**illustration on next page**).

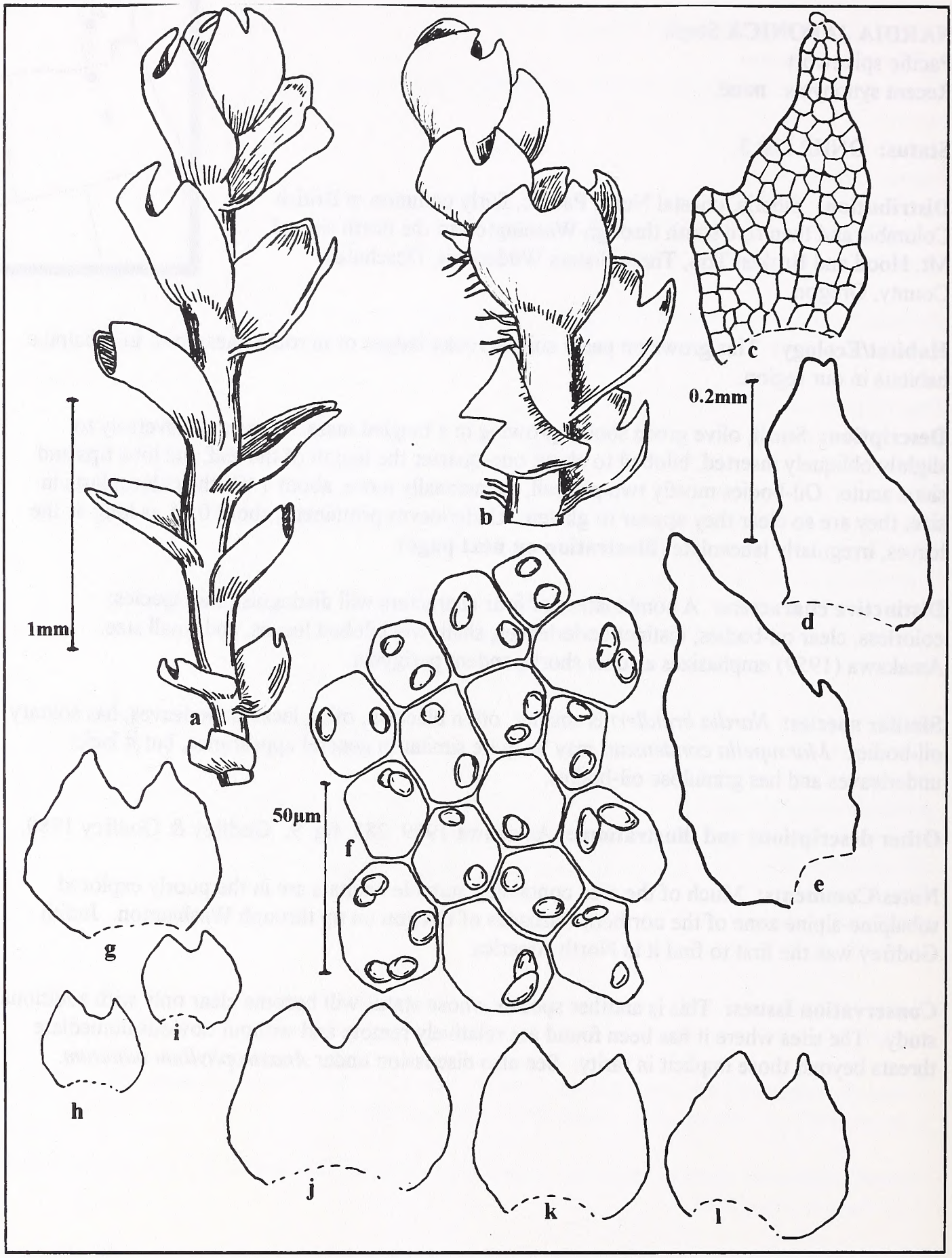
Distinctive characters: A combination of four characters will distinguish this species: colorless, clear oil-bodies; distinct underleaves, shallowly bilobed leaves, and small size. Amakawa (1959) emphasizes also its short-pendent perigynia.

Similar species: *Nardia breidleri* is smaller, often blackish, often lacks underleaves, has solitary oil-bodies. *Marsupella condensata* may be quite similar in general appearance, but it lacks underleaves and has granulose oil-bodies.

Other descriptions and illustrations: Amakawa 1959: 283, fig. 9. Godfrey & Godfrey 1980.

Notes/Comments: Much of the area containing suitable habitats are in the poorly explored subalpine-alpine zone of the northern Cascades of Oregon on up through Washington. Judith Godfrey was the first to find it in North America.

Conservation Issues: This is another species whose status will become clear only with additional study. The sites where it has been found are relatively remote and without obvious immediate threats beyond those implicit in rarity. See also discussion under *Anastrophyllum minutum*.



Nardia japonica a,b: shoots, 1 mm scale. c,d,e: underleaves, 0.2mm scale. f: cells with oil-bodies, 50 µm scale. g,h,i,j,k,l: leaves, 1mm scale.

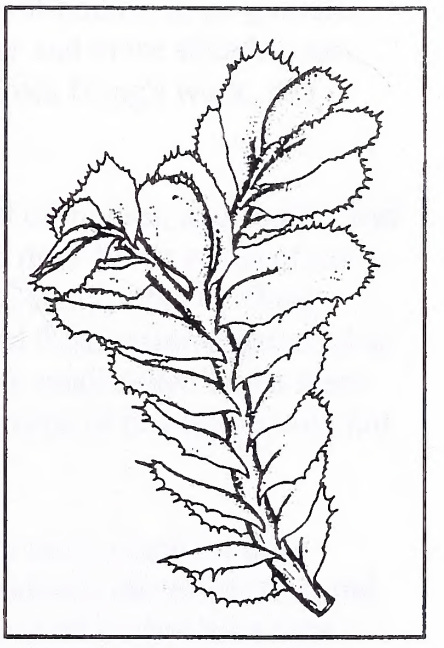
PLAGIOCHILA SATOI Hatt.
Sato's cedarshingle
Recent synonyms: none.

Status: ROD Table C-3.

Distribution: North Pacific, south in western North America to Douglas County, Oregon.

Habitat/Ecology: Poorly characterized; reported from lower elevation riparian forests, on cliffs, rocks and bark.

Description: Medium to large, yellowish-green, erect shoots in cushions. Leaves in two rows, asymmetrically ovate, with a trough near the base. This trough is the result of a dip in the middle of the line of attachment of the leaf to the stem (an excellent generic character). There is a group of 20-30 elongated cells (called a vitta) at the median base of the leaf, at the bottom of the trough.

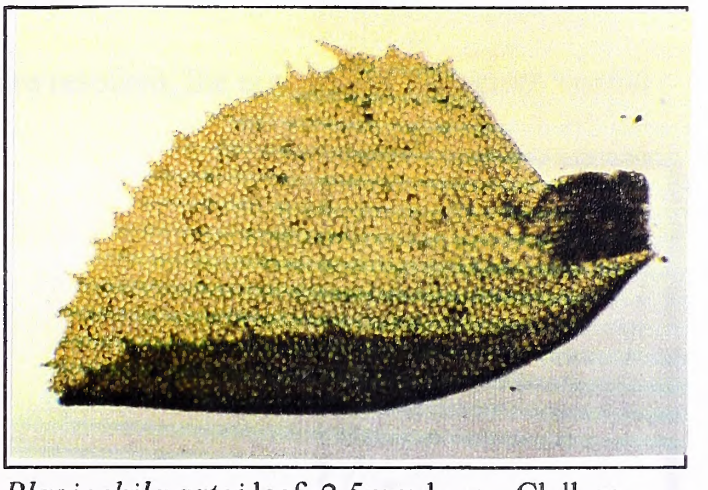


Plagiochila satoi, 12X. From Inuoe 1958, fig. VIII-12.

Distinctive characters: Sharp teeth on leaf margins, always present, and the vittae of elongated cells at the leaf bases are reputed to be the main diagnostic characters for this species. Leaf cuticle is smooth and dull, not shiny.

Similar species: *Plagiochila semidecurrens* shares the sharply-toothed leaf margin, but it has shiny leaf surfaces when dry. *Plagiochila asplenioides* has a similar dull leaf surface, but (supposedly) lacks the spiny leaf margins. See Notes/Comments, below.

At arm's length in the field a *Scapania* bears a superficial resemblance to *Plagiochila*, but a quick look with a hand lens will reveal the bilobed, folded leaves of *Scapania*.



Plagiochila satoi leaf, 2.5mm long. Clallam County, WA., *Schofield 28209*.

Other descriptions and illustrations: Hong 1980a. Hong 1992. Inuoe 1958: 51, fig. VIII.

Notes/Comments: *Plagiochila satoi* has proven to be a difficult taxon to handle. The most recent regional treatment of the genus (Hong 1992) should be presumed the most authoritative for understanding the regional taxa of *Plagiochila*; it is the basis for considering *P. satoi* a potential species of conservation

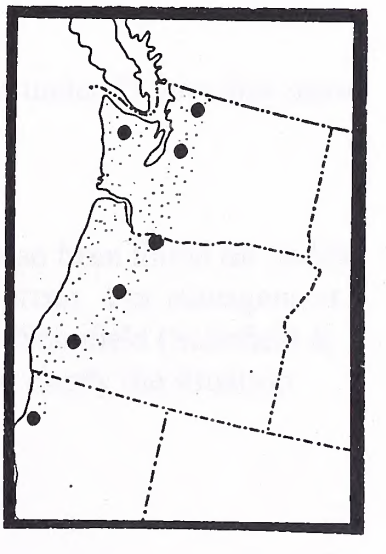
concern. However, part of the problem is that the keys in Hong's 1992 paper are not adequate for consistent identification of specimens. The critical couplet is based on characters which are unreliable: leaf dentition and presence or absence of vittae. In an extensive study of specimens from the region, it was found that the large teeth and presence of vittae are not correlated, and that each character may vary from one condition to the other in the same population, often the same plant. It is not possible to confidently separate *P. asplenioides* from *P. satoi* using these characters.

The author has found three well-correlated characters which distinguish two lowland species in western Oregon: oil-body number, oil-body morphology, and leaf cell size. There is a widespread and ecologically flexible species which typically has fewer oil-bodies; large-globular, few-segmented oil-bodies; and larger leaf cells. This taxon is the larger and more abundant one and is here assumed to be *P. asplenioides*. Contrary to expectations from Hong's work, this species often has vittae and rather prominent teeth.

The smaller, less common taxon has more oil-bodies; finely-segmented oil-bodies; and smaller leaf cells. This taxon is less common, but seems to be most frequent in the drier forest zones of the region. The specimen (*Schofield 23012*) from Canyonville, Douglas County, cited by Hong (1992) as *P. satoi*, appears to be this taxon. The site was relocated and fresh material gathered so that the oil-body characters could be studied. Many populations of this small-celled taxon seem to lack vittae and are often only moderately dentate. Herbarium specimens of this type would not key to *P. satoi* using present keys.

If this small-celled taxon is indeed *Plagiochila satoi*, then it is probably more common than presently presumed. Because herbarium specimens cannot yet be confidently identified, the total range of this plant will have to rely on freshly collected specimens whose oil-bodies have been examined. Oil-body characters are lost in herbarium specimens, so that historical specimens can be placed only provisionally. Eventually, molecular techniques may be utilized to identify these specimens.

Conservation Issues: Until the taxonomic issues are resolved, the ecological parameters needed by *Plagiochila satoi* cannot be clearly defined.



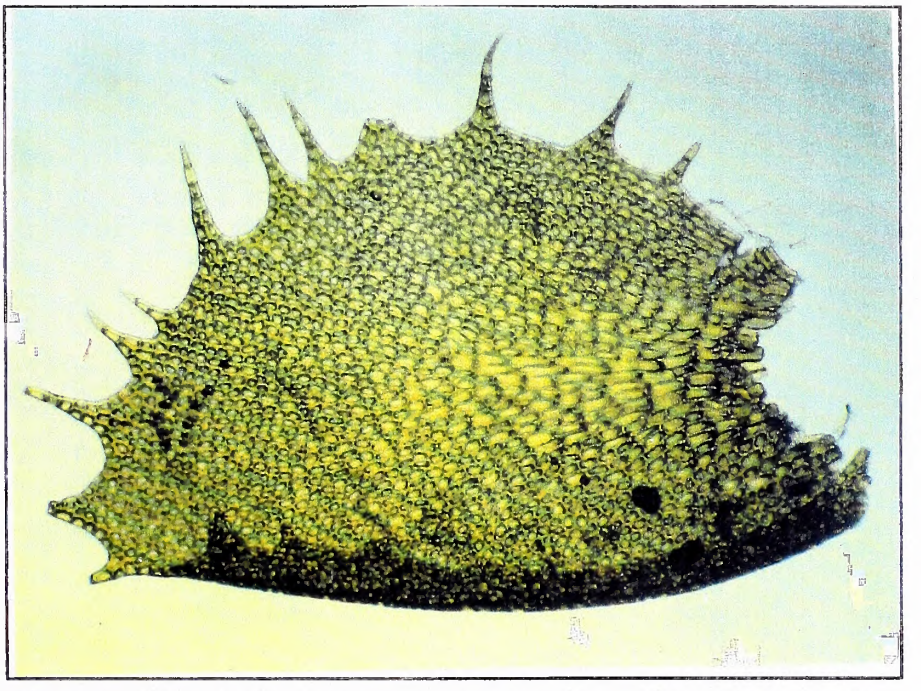
PLAGIOCHILA SEMIDECURRENS var. ALASKANA (Evans) Inoue
Alaska cedar-shake
Recent synonyms: none.

Status: ONHP List 3; ROD Table C-3.

Distribution: Saddle Mountain, Clatsop County, Oregon, and northward.

Habitat/Ecology: On wet rocks and trees. Apparently restricted to sites with northern, boreal affinities. In British Columbia it occurs on rocks near the coastal beaches, in Oregon on N-facing moist cliffs near the summit of Saddle Mountain. A number of other rare liverworts are reported as associates from the Saddle Mountain locality (Schofield & Godfrey 1979), including *Herbertus sakuraii, Radula obtusiloba* and *Tritomaria quinquedentata.*

Description: Large, yellowish to blackish-brown liverwort with succubous leaves; curved insertion of leaf produces a trough in the middle of the leaf at its base in robust specimens. Erect stems in tight tufts, mostly lacking rhizoids.



Plagiochila semidecurrens leaf, 1.5mm long. British Columbia, *Schofield 15835.*

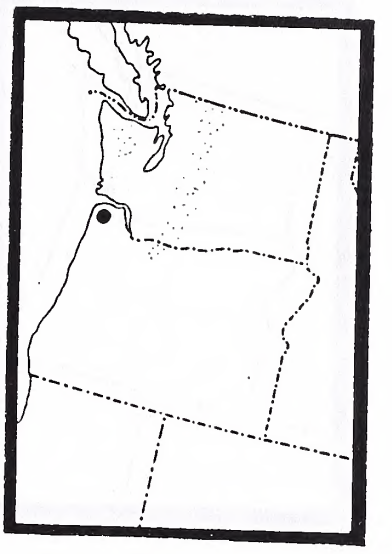
Distinctive characters: The shiny leaves are very distinctive, few liverworts have this feature. Leaf margins with spiny teeth. Cells at base of leaf are distinctly elongated, forming a short vitta.

Similar species: *Plagiochila satoi* and sometimes *Plagiochila asplenioides* have spiny leaf margins but the leaf surface is not shiny. See Notes/Comments under *Plagiochila satoi.*

Other descriptions and illustrations: Hong 1992. Schofield 1968.

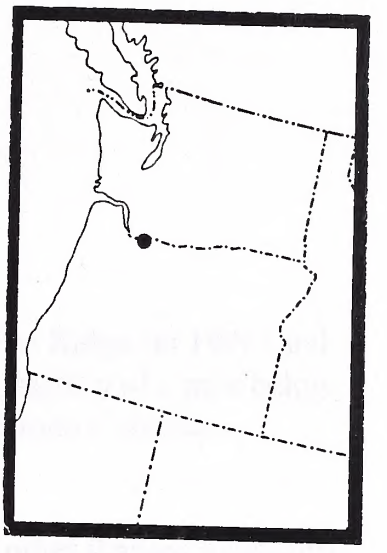
Notes/Comments: *Plagiochila semidecurrens* var. *semidecurrens* has also been found on Saddle Mountain. It is generally like the typical variety but is smaller and more green. For management purposes the varieties can be ignored and the species treated as a whole. Schofield (Schofield & Godfrey 1979) called them "minor subspecies." Molecular analysis might clarify the situation.

Conservation Issues: see *Herbertus sakuraii.*



Plagiochila semidecurrens

PORELLA VERNICOSA var. FAURIEI (Steph.) M. Hara
Pacific scalemoss
Recent synonyms: *Porella fauriei* (Steph.) Hatt.

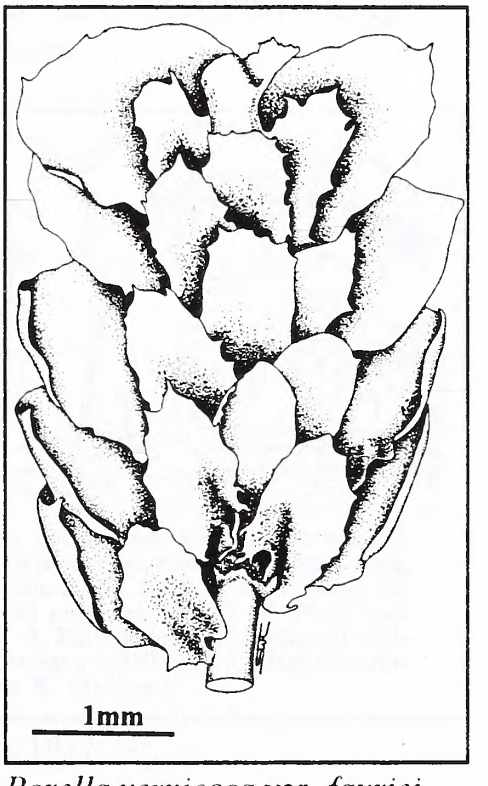


Status: ONHP List 2.

Distribution: Eastern Asia; Attu; Columbia River Gorge.

Habitat/Ecology: Not known; probably on trees or rocks.

Description: Large, dark green plants in sprawling patches. Leaves overlap closely, appearing turned up (incubous) from either above or below. Lateral leaves with a small lobe folded up on the underside (lobule). Underleaves ca 1mm long, often squarish at the tip. Irregular teeth or cilia frequent along margins of underleaves and ventral lobules.



Porella vernicosa var. *fauriei* from Columbia River Gorge. drawn by S. Allison.

Distinctive characters: A scalemoss with sharply dentate lobules and underleaves. Probably peppery tasting, like most members of the *P. vernicosa* group.

Similar species: The genus is easy to recognize but separating this species from the others may be challenging at first. Gaining familiarity with the three common species--*P. navicularis, P. cordaeana,* and *P. roellii*--will aid discrimination. Of the three common species, most similar is *P. cordaeana*, which usually has underleaves widely spaced on the stem and lacking copious teeth.

Other descriptions and illustrations: Hong 1983.

Notes/Comments: Because there is no other variety of *P. vernicosa* in North America, it might be more convenient to refer to this simply as *P. fauriei*. Whatever it is called, it is known only from two places in North America. Note that Hong (1983) misread "Veneta" for "Oneonta" due to poor handwriting on the original label, thus he mistakenly cited the Oregon specimen from Lane County. The label has, "Triple Falls, Oneonta" which is in Multnomah County.

Conservation Issues: Until an extant population of this plant can be found, little can be said about its potential viability. It has been found only once, in 1920. The area around Triple Falls has been visited recently without success but there are many square miles of likely habitat still to be searched.

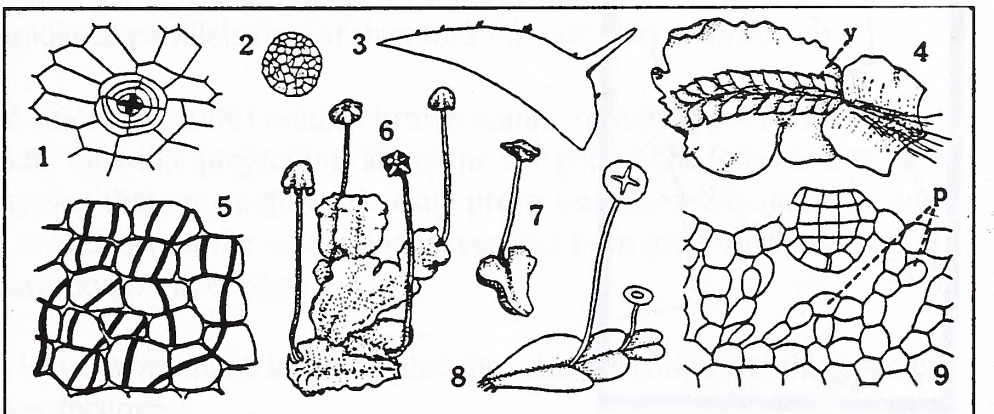
PREISSIA QUADRATA (Scop.) Nees
Blister-ribbon
Recent synonyms: none.

Status: ONHP List 3.

Distribution: Circumboreal; Columbia River Gorge (both sides), Elkhorn Ridge (in 1996) and Wallowa Mountains. Also reported, "along the Larch Mountain Trail a fraction of a mile below the Palmer Road crossing" (Griffin and Thurston 1935); Humboldt and Mono Counties, California.

Habitat/Ecology: Terrestrial, on damp mineral soil, in the company of other thalloid liverworts. Reputedly a strict calciphile (Schuster 1992a) but not strongly so in the Columbia River Gorge. The Sandy River population seems to develop only female receptacles.

Description: A thallose liverwort resembling *Marchantia*. Like *Marchantia*, it has sexual organs in receptacles on elevated stalks. It is monoecious, both sexes usually developing on the same plant. The male receptacles are half as high as the female. *Preissia* has no gemmae.



Preissia quadrata. 1, Pore of thallus, dorsal view, x 90. 2, Spore, x 125. 3, Ventral scale, x 12.5. 4, Portion of thallus, ventral view, (*v*) ventral scale, x 3.5. 5, Thickenings in wall of sporangium, x 170. 6, Plant with female receptacles, x 0.75. 7, Plant with antheridial receptacle, x 0.75. 8, Plant with both male and female receptacles, x 0.75. 9, Part of vertical section of thallus through pore, (*p*) photosynthetic filaments, x 160. (2, 3, after Casares-Gil; 8, after Massalongo; the others after K. Mueller.)

Preissia quadrata from Frye & Clark 1937: 96.

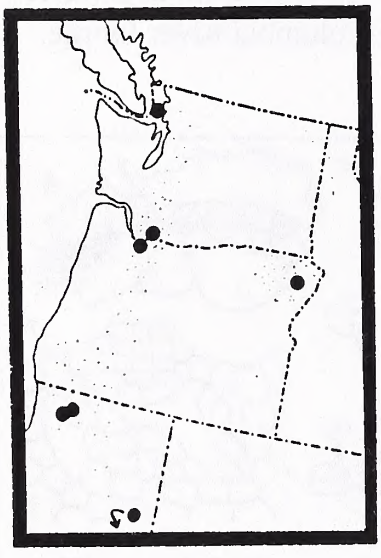
Distinctive characters: The cells surrounding the pores are whitish, lacking chloroplasts, and form mounds that look like little blisters. Dried herbarium specimens are notably white-dotted as a result. The X-shape of internal pore cells is evident in epidermal preparations. Fresh plants have a peculiar odor that most people find unpleasant.

Similar species: Only *Marchantia* shares the compound, barrel-shaped pores of *Preissia*. The pores in *Marchantia* may be blister-like as in *Preissia*. *Marchantia*, a very common genus, usually has gemmae-cups on the surface of its thallus and sexual structures that differ conspicuously (see keys). *Marchantia* and *Conocephalum* (another common and similar looking liverwort) both smell sweet compared to *Preissia*.

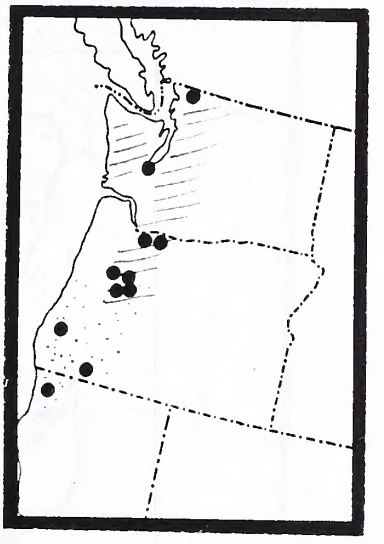
Other descriptions and illustrations: Crum 1991:91, figs 25e, 30. Frye & Clark 1937:96, *96*. Müller 1954: 386, fig. 83. Schuster 1992a, p. 363. Smith 1990: 317, fig. 139. Vitt et al. 1988, p. 153 (color photo).

Notes/Comments: One of the specimens cited by Frye & Clark (1937; identified by Lois Clark in the University of Washington Herbarium) as *Cryptomitrium tenerum*, from the Washington side of the Columbia River Gorge, has proven to be *Preissia*.

Conservation Issues: *Preissia quadrata* is very rare in this region. The population along the Sandy River in Oregon is growing on an old, stabilized road cut. The substrate has the texture of a consolidated till. The entire population appears to be female, leading to the hypothesis that it may be a clone having arisen from germination of a single spore. The habitat is unusual also, in that its calcareous content is not evident. On Elkhorn Ridge the plants grows only where clearly associated with limestone.



PTILIDIUM CALIFORNICUM (Aust.) Underw.
Pacific fuzzwort
Recent synonyms: none.



Status: ROD Table C-3 (California only); Final SEIS Table J2-8a.

Distribution: Endemic to the west coast of North America from northern California to SE Alaska. Common from Lane County, Oregon, northward.

Habitat/Ecology: Typically on bark at base of standing trees or recently fallen logs; rarely on other organic substrates. At the southern end of its range (Oregon and California) this species is distinctly restricted to middle elevation forests. In the central Cascades of Oregon it is most abundant in older forests of the *Abies amabilis* zone, where it is one of the dominants of the cryptogam community. Its maximum abundance parallels that of the moss *Rhytidiopsis robusta*.

Description: Small, green to (more typically) reddish brown plants, resembling a fuzzy mat. Leaves deeply lobed with slender cilia-like projections along the margins of the lobes and at lobe tips. Leaves so closely overlapping that only a mass of ciliate projections is visible under a hand lens. Underleaves prominent, less than half the size of the leaves and even more finely divided into slender projections. (Illustration on next page.)

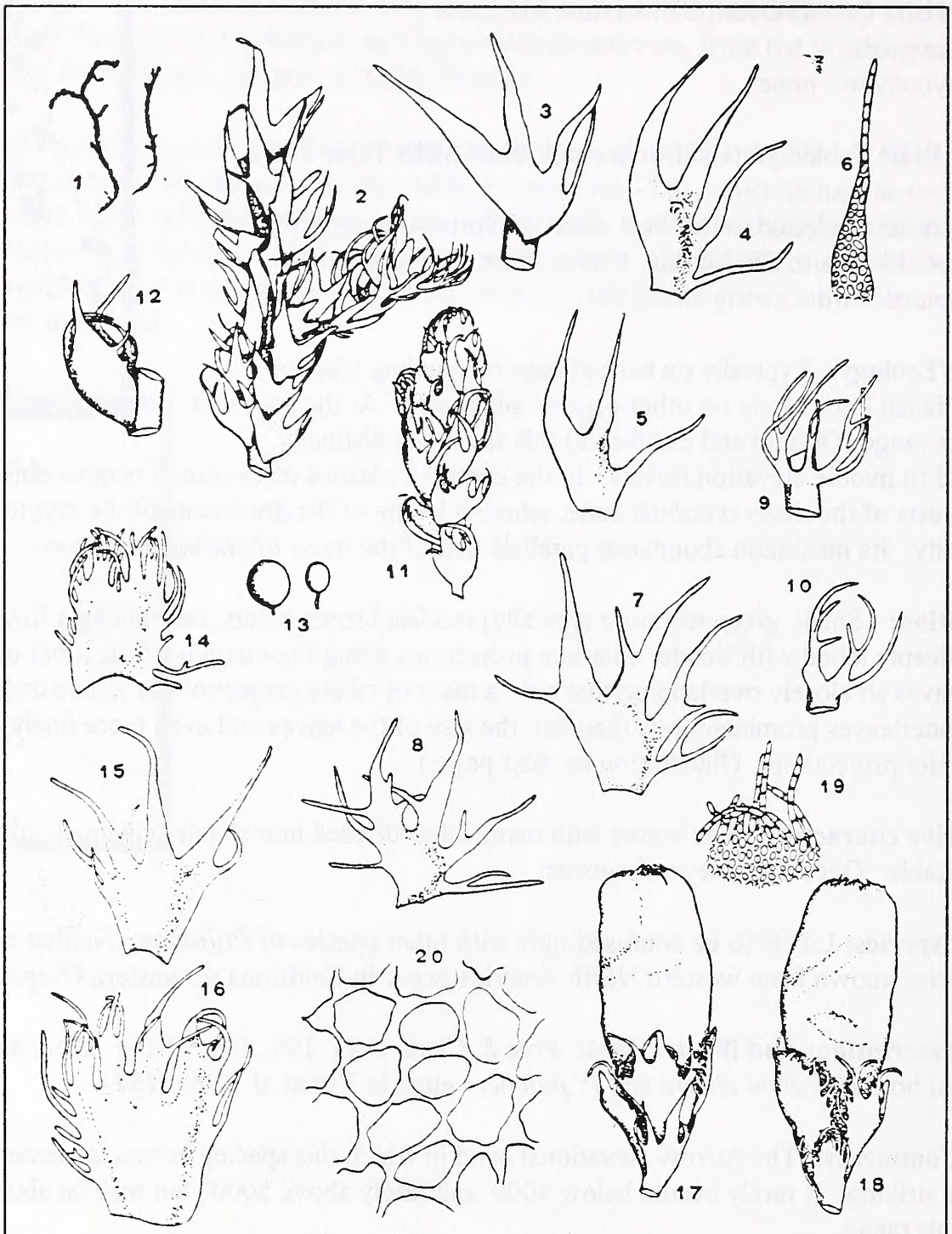
Distinctive characters: The leaves with many lobes divided into slender cilia make this species unmistakable. Once seen, never forgotten.

Similar species: Likely to be confused only with other species of *Ptilidium*. Neither of the other two species known from western North America occur in California or western Oregon.

Other descriptions and illustrations: Frye & Clark 1943: 195, *196*. (Note: there are color photos of both *Ptilidium ciliare* and *P. pulcherrimum* in Vitt et al. 1988: *154*.)

Notes/Comments: The narrow elevational band in which this species occurs in western Oregon is rather striking. It rarely occurs below 3000' and rarely above 5000', but may be abundant within this range.

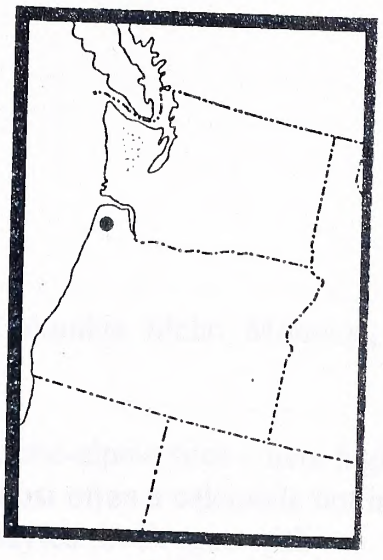
Conservation Issues: The stability of this species in the central part of its range seems secure. At the southern end of its range (northern California through Curry, Jackson, Josephine, and Klamath Counties, Oregon) its survival may depend on protection of the few known sites as dispersal sources.



Ptilidium californicum. 1, Plants, x 1. 2, Part of plant, x 12. 3, Stem leaf, dorsal view, x 23. 4, Stem leaf, ventral view, x 23. 5, Stem leaf, 3-cleft, ventral view, x 23. 6, Typical apex of leaf-segment, x 41. 7, Stem leaf, ventral view, x 23. 8, Branch leaf, ventral view, x 23. 9-10, Underleaves, x 23. 11, Male inflorescence, x 12. 12, Male bract, x 23. 13, Antheridia, x 23. 14, Bracteole, x 23. 15, Underleaf just beneath the bracteole, x 23. 16, Bracteole, x 23. 17, Ventral view of perianth and female bracts, x 12. 18, Dorsal view of perianth and female bracts, x 12. 19, Portion of mouth of perianth, x 41. 20, Leaf cells, x 225. (All after Howe.)

Ptilidium californicum from Frye & Clark 1943: 196.

RADULA BRUNNEA Steph.
brown flatwort
Recent synonyms: none.



Status: ONHP List 3; ROD Table C-3.

Distribution: Japan, E Asia; known in North America only from Saddle Mountain, Clatsop County, Oregon.

Habitat/Ecology: Peaty ledges on cliffs sheltered by the ridge top (Saddle Mountain). Grows in thick mats, occasionally mixed in with other bryophytes. See *Plagiochila semidecurrens* for associated liverworts.

Description: Medium-large, dark brown shoots with numerous minute side branches at right angles to the stem. These side branches largely hidden by the leaves and not visible from above. The leaves have a separate lobe folded up on the underside, the ventral lobe ca one-third the size of the dorsal lobe. Underleaves absent. Gemmae absent.

Distinctive characters: The most notable feature is the profusion of tiny branchlets with very reduced leaves below almost every leaf along the stem. The dark brown color is also distinctive.

Similar species: From above this species looks more like a *Porella* than a *Radula*, since the regionally common species of *Radula* are smaller and a soft green. Nothing else in our area has the numerous branchlets of *Radula brunnea*.

Other descriptions and illustrations: Schofield & Godfrey 1979.

Radula brunnea, 30X. Saddle Mountain, *Schofield 68047*.

Notes/Comments: This species is of general interest because of its remarkable disjunction from eastern Asia, a solitary locality on the west coast of North America. See discussion in Schofield & Godfrey (1979).

Conservation Issues: *Radula bolanderi* is apparently quite abundant on Saddle Mountain and seems likely to be stable there if conditions do not change.

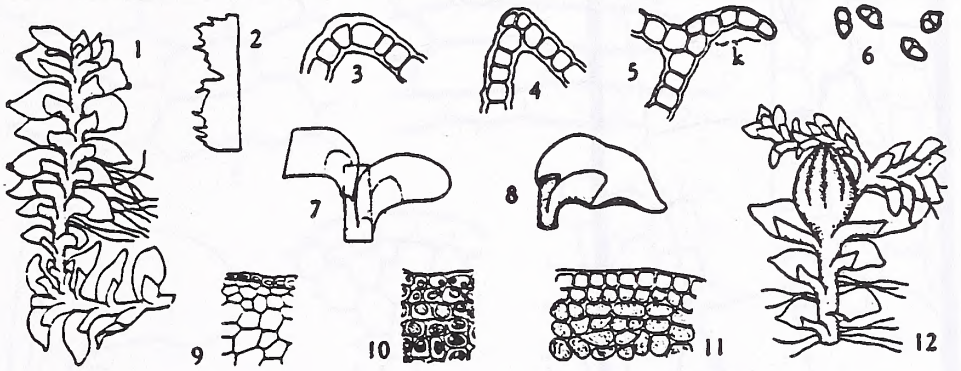
SCAPANIA GYMNOSTOMOPHILA Kaal.
puckered spadewort
Recent synonyms: *Diplophyllum gymnostomophilum* (Kaal.) Kaal.

Status: ONHP List 3.

Distribution: Rare worldwide; isolated stations in Alaska, British Columbia, Idaho, Montana, and in the Columbia River Gorge, Multnomah County, Oregon.

Habitat/Ecology: Shady cliffs or rocks next to streams in northern arctic-alpine sites where high humidity and cool temperatures are maintained throughout the year; most often a calciphile but in Oregon known from acidic basalt. Regular associates are other bryophytes (in Oregon with *Anacolia menziesii*, *Porella*, and other cliff plants) which occupy the same type of microsite, rather than any particular higher plant or vascular plant community. It has been found from tundra to evergreen and deciduous forests.

Description: Small, dark green to blackish, more-or-less sprawling shoots in small patches, usually growing with other bryophytes. Leaves in two rows, unequally bilobed, the smaller dorsal lobe folded up over the ventral lobe. Gemmae (missing on Oregon plants) 2-celled, reddish-brown. Cells with a single (rarely 2), brown, plate-like oil-body that fills most of the cell. In most specimens these oil-bodies persist long after the plant has been dried, in some cases for decades.



Diplophyllum gymnostomophilum. 1, Part of gemmiparous plant, dorsal view, x 8.5. 2, Mouth of perianth, x 42. 3-5, Cross sections through three keels, the last one with wing (*k*), x 152. 6, Four gemmae, x 186. 7, Part of plant, ventral view, x about 11. 8, Leaf, dorsal view, x 21. 9, Part of cross section of stem, x 152. 10, Cells along leaf margin, containing oil bodies, x 152. 11, Cells along ventral margin of leaf, x 186. 12, Part of plant with perianth, dorsal view, x 8.5. (1-2, 6, 8, 11-12, after K. Mueller; 3-5, 7, 9-10, after Buch.)

Scapania gymnostomophila from Frye & Clark 1946: 579.

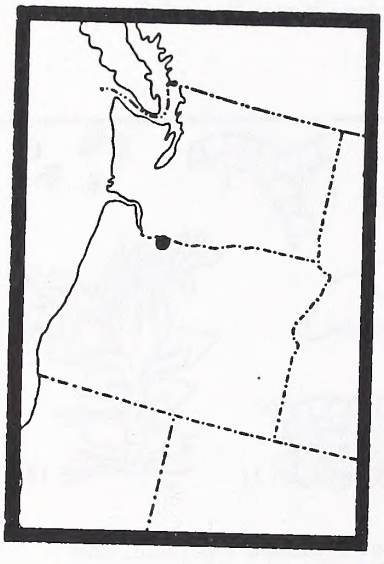
Distinctive characters: A folded leaf with very small dorsal lobes and persistent, solitary oil-bodies. The perianth (rarely produced and not seen in regional material) is contracted at the mouth and more like a *Diplophyllum* than a typical *Scapania*.

Similar species: Before microscopic examination of oil-bodies, it might be taken for a species of *Diplophyllum* or a very small *Douinia ovata*. The small size and dark color of *Scapania gymnostomophila* should rule out these possibilities. *Scapania cuspiduligera*, common in adjacent regions, is very similar to *S. gymnostomophila* but its dorsal lobes are almost as large as the ventral lobes.

Other descriptions and illustrations: Frye & Clark 1946: 578, *579*. Godfrey 1977. Hong 1980. Müller 1957: 922, fig. 327. Schuster 1953: 441, pl. 39. Schuster 1974, p. 298. Smith 1990: 176, fig. 73.

Notes/Comments: The oil-bodies of this species are notable for their longevity; they persist for decades in dried herbarium specimens. This species is recommended for the ONHP List 1, since it appears to be rare worldwide.

Conservation Issues: The only known Oregon site is extremely difficult of access and unlikely to suffer from disturbance or redundant collecting. The challenge in assessing long term viability will be training the next generation of bryologists to relocate the known population. The general rarity of the species makes it unlikely that it will turn out to be frequent in the Pacific Northwest.



SCAPANIA OBSCURA (Arn. & Jens.) Schiffn.
scorched spadewort
Recent synonyms: *Scapania subalpina* var. *haynesiae* Frye & Clark

Status: ONHP List 3.

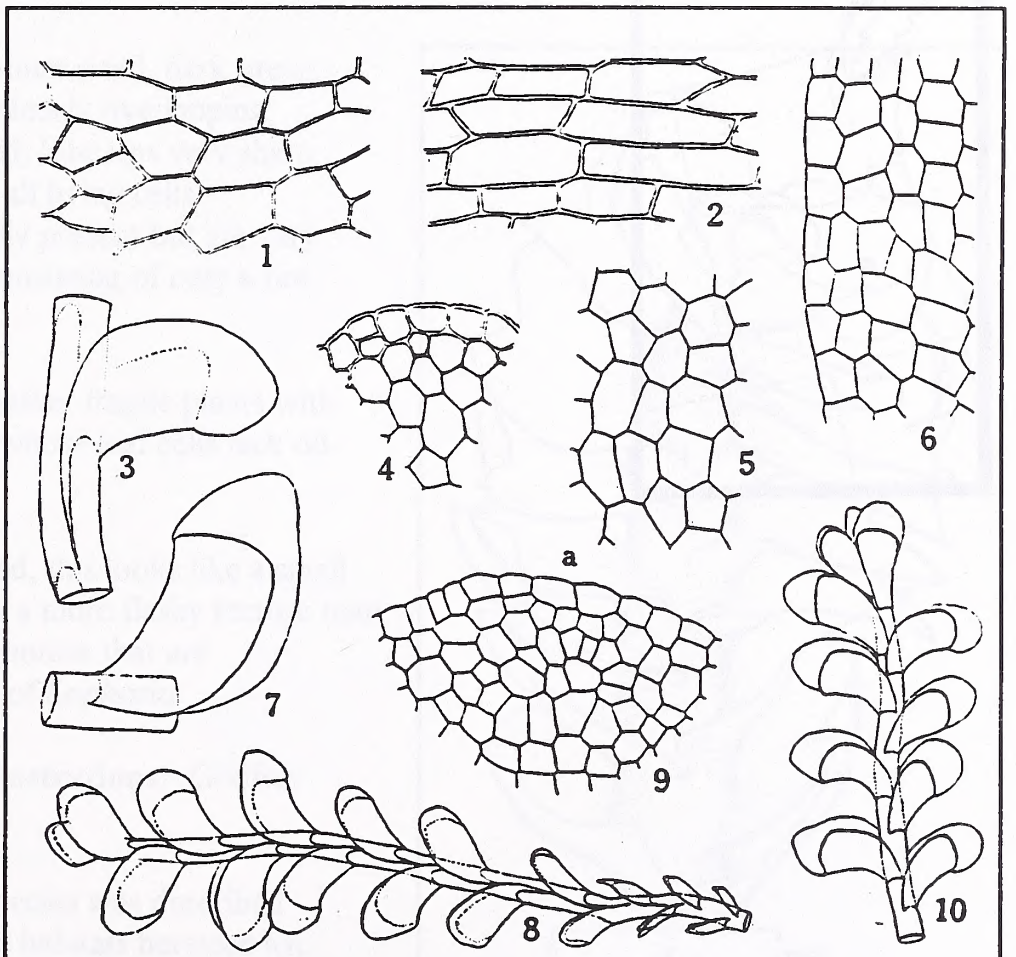
Distribution: Very rare world-wide; Scandinavia and the Alps. In North America known with certainty only from Alberta and Oregon.

Habitat/Ecology: Arctic-alpine, terrestrial, in seepage area or next to streams where substrate is perennially saturated. This species is an aquatic or near aquatic, apparently always growing close to flowing water if not actually in streambed; it is inundated during times of snowmelt. As far as is known, it grows mainly in exposed sites.

Description: Small, dark-brown to black shoots with bilobed leaves that are not very tightly folded. Lobe tips quite rounded, spreading back from stem. The dorsal lobe is almost as large as the ventral lobe.

Distinctive characters: Searching for scorched, blackened little liverworts in dense mats next to cold, running water in alpine/subalpine sites is the key to discovering this plant. Positive identification depends on microscopic examination.

Similar species: The loosely folded lobes and dark color make this look very much like *Gymnocolea inflata*. *Gymnocolea* has minute underleaves which are inconspicuous but detectable by careful examination, and more equal and unfolded leaf lobes.



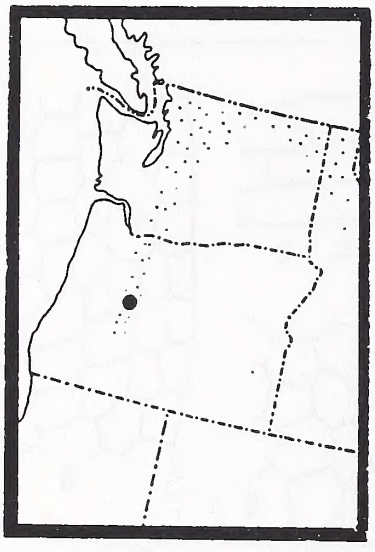
Scapania subalpina var. *haynesiae*. 1, Cells of base of ventral half of leaf, x 250. 2, Surface view of epidermal cells of stem, x 250. 3, Leaf, ventral view, x 35. 4, Part of cross section of stem, x 250. 5, Cells of middle of ventral half of leaf, x 250. 6, Cells along middle of ventral margin of leaf, x 250. 7, Leaf, dorsal view, x 35. 8, Shoot, ventral view, x 16. 9, Cells around apex (*a*) of ventral lobe of leaf, x 250. 10, Shoot, dorsal view, x 35. (All original.)

Scapania obscura from Frye & Clark 1946: 639.

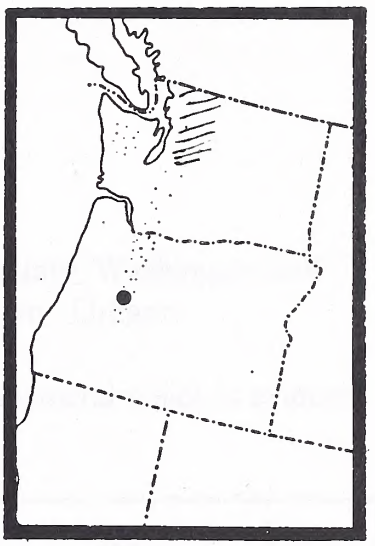
Other descriptions and illustrations: Frye & Clark 1946: 638, *639* (as *S. subalpina* var. *haynesiae*). Müller 1957: 1000, fig. 369.

Notes/Comments: This species is not yet well defined. The treatment here assumes a narrow interpretation that would exclude the material treated by Schuster (1974). The basis of the current interpretation is the remarkable consistency among collections of small, dark plants from Scandinavia, the Alps, Canada, and Oregon. This should probably be placed on ONHP List 1, since it appears to be rare worldwide.

Conservation Issues: At present, this species must be viewed like the other rare, arctic-alpine and high-elevation boreal bryophytes. Known sites are presumably protected by remoteness and lack of general threats beyond local disturbance.



SCHOFIELDIA MONTICOLA J. Godfrey
alpine masterwort
Recent synonyms: none.



Status: ONHP List 3.

Distribution: Endemic to Cascade Mountains of the Pacific Northwest, including British Columbia. In Washington found in the Cascades S to Mt. Rainier; in Oregon known only from Three Sisters Wilderness, Willamette National Forest, Lane County.

Habitat/Ecology: Terrestrial, on peaty soil, under heather or beside small streams, subalpine-alpine, with *Cassiope*, *Phyllodoce*, and *Moerckia*.

Description: Small to medium sized, dark green, sprawling shoots. Leaves closely overlapping, spreading, shallowly bilobed; lobe tips very sharp. Oil-bodies are absent from all living cells. Underleaves are occasionally present but are very small and inconspicuous, consisting of only a few cells.

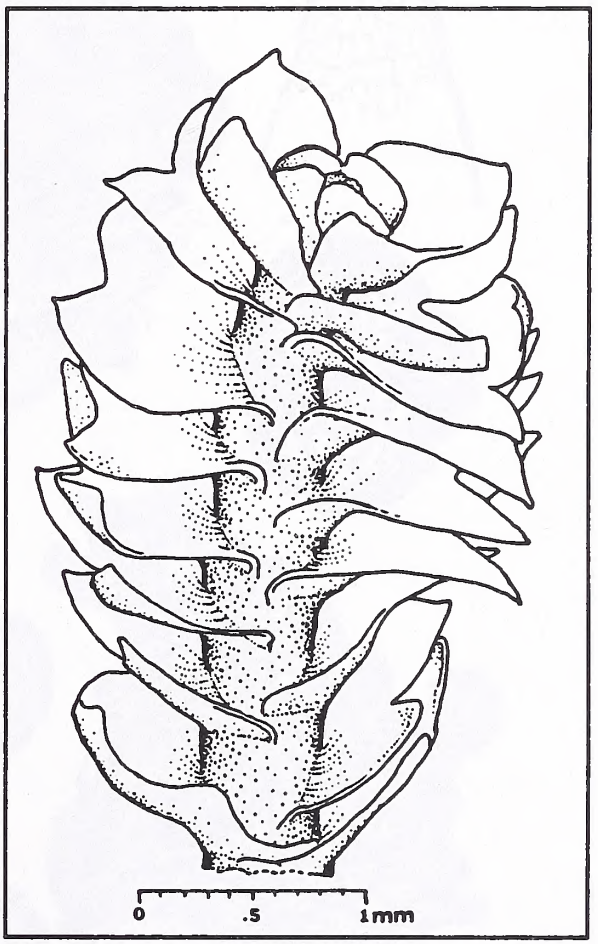
Distinctive characters: Rather fragile plants with dark green, bilobed leaves whose leaf cells lack oil-bodies.

Similar species: In the field, this looks like a small species of *Lophozia*. It has a more fleshy texture than *Lophozia* and lacks the oil-bodies that are characteristic of all species of *Lophozia*.

Other descriptions and illustrations: Godfrey 1976.

Notes/Comments: This species was described relatively recently. Suitable habitats between Mt. Rainier and the Three Sisters has been little explored by botanists who notice liverworts.

Conservation Issues: See under *Scapania obscura*.



Schofieldia monticola from Oregon, *Wagner s.n.* 8 Aug 1982.

SPHAEROCARPOS HIANS C. Haynes
trumpet bottlewort
Recent synonyms: none.

Status: ONHP List 1.

Distribution: Historically known only from near Pullman, Whitman County, Washington and Moscow, Latah County, Idaho; recently found in Corvallis, Benton County, Oregon.

Habitat/Ecology: On mud of river bank. Poorly known. A seasonal ephemeral which is evident in summer (Pullman) and fall (Corvallis), when the water levels are low.

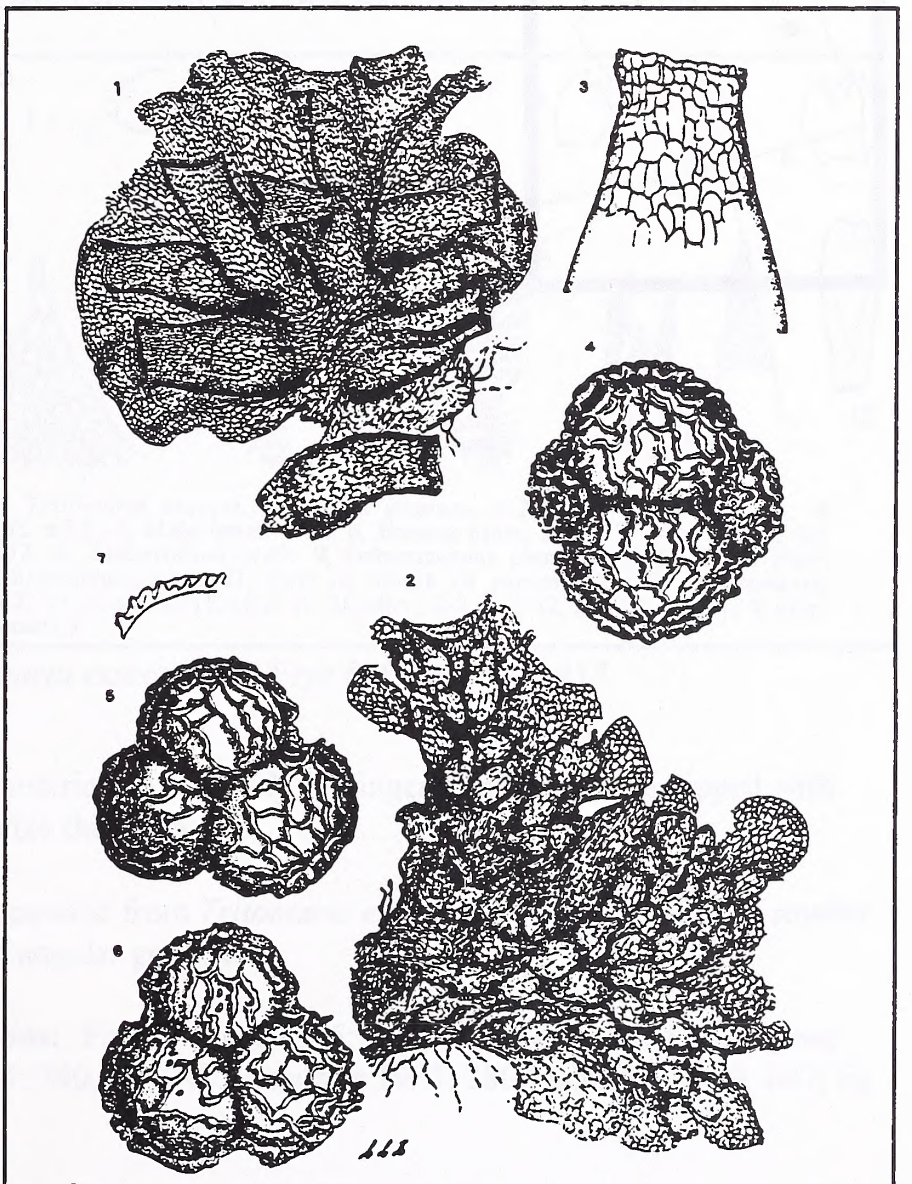
Description: Pale green rosettes up to 8mm across, covered with flasks (involucres) that have a flaring mouth.

Distinctive characters: The flaring mouth of the involucres is diagnostic.

Similar species: The only other species of the genus in our area, *S. texanus*, has flasks which are closed at the mouth with only a tiny, pore-like opening. The latter is weedy on disturbed, open ground; maturing in late spring.

Other descriptions and illustrations: Frye & Clark 1937: 106, *107*.

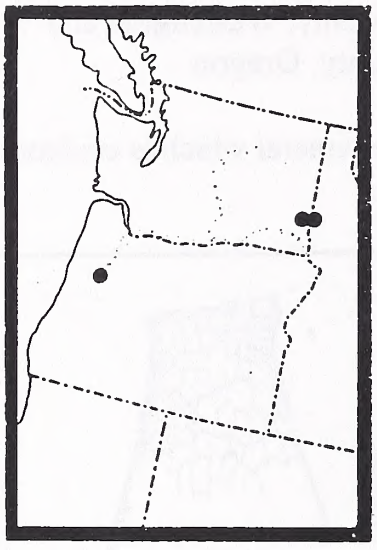
Notes/Comments: The widely disjunctive range of this species is puzzling. It has probably been overlooked because of its inconspicuous nature. It is not likely to be noticed unless someone is specifically looking for ephemeral liverworts.



Sphaerocarpus hians. 1, Plant with female involucres, x 11. 2, Plant with antheridial involucres, x 24. 3, Mouth of female involucre, x 38. 4-6, Tetrads of spores, x 308. 7, Ridges of spores in optical section, x 308. (All after Haynes.)

Sphaerocarpos hians from Frye & Clark 1937: 107.

Conservation Issues: It seems possible that *Sphaerocarpos hians* could turn up anywhere in the Columbia basin. It is unknown how spores are transported; either water or birds could account for the known distribution. Given the ephemeral habitat and limited known distribution, it seems that this species could be vulnerable to habitat modification. Accurate assessment is impossible without additional information.



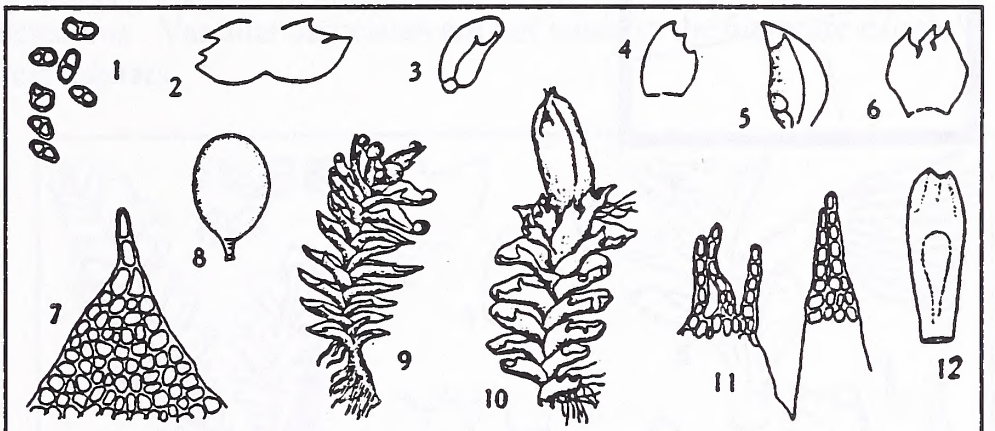
TRITOMARIA EXSECTA (Schmid.) Schiffn.
little brownwort
Recent synonyms: none.

Status: ONHP List 2.

Distribution: Circumboreal; NE Washington; N Idaho; erroneously reported from Oregon.

Habitat/Ecology: Grows on organic substrates, typically compacted decomposing litter, rotting wood, or peaty soil, sometimes humus over rocks, where perpetually shady, cool and moist. It is associated with other bryophytes of such microsites, e.g., *Blepharostoma, Lophozia, Cephalozia, Lepidozia*. Hong (1994) reports it from branches of *Alnus* and *Malus*.

Description: Small, yellowish-green to brownish-green plants with two rows of asymmetrical leaves, growing in small tufts among other liverworts and mosses. Leaves 2- to 3-lobed with the dorsal lobe slender, divergent, positioned 2/3 up the margin. Reddish-brown, ovoid gemmae in globular masses at the tips of the leaf lobes. Perianths rare; underleaves lacking.



Tritomaria exsecta. 1, Seven gemmae, x 212. 2-3, Leaves, x 8.5. 4, Leaf. x 8.8. 5, Male bract, x 17. 6, Female bract, x 8.8. 7, Cells of leaf tip, x 212. 8, Antheridium, x 60. 9, Gemmiparous plant, x about 10. 10, Plant with perianth, x 8.8. 11, Part of mouth of perianth, x 212. 12, Perianth, x 8.5. (1, 4, 6-7, 10-11, after K. Mueller; 2-3, 5, 8, 12, after Pearson; 9, after Hooker.)

Tritomaria exsecta from Frye & Clark 1945: 417.

Distinctive characters: The asymmetrical leaves with the finger-like dorsal lobe, tipped with masses of ovoid gemmae, characterize this species.

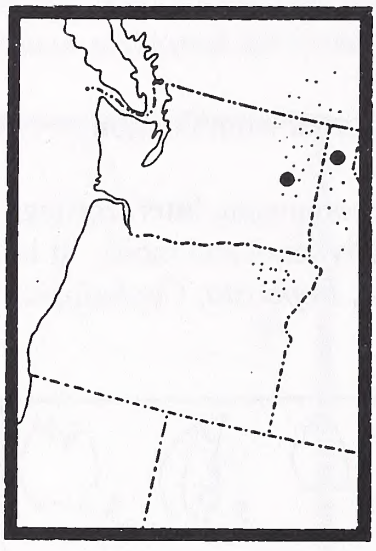
Similar species: This species is separated from *Tritomaria exsectiformis* on the basis of smaller cells and having rounded instead of angular gemmae.

Other descriptions and illustrations: Frye & Clark 1945: 417, *417*. Hong 1994. Kitagawa 1966: 115, fig. XXIII. Müller 1954: 740, fig. 242. Schuster 1953: 380. Schuster 1969: 647, fig. 223. Smith 1990: 128, fig. 55.

Notes/Comments: The basis for listing this species from Oregon appears to have originated from a misidentified specimen, and is believed to be an error. Hong (1994) maps a single site from NE Washington without citation of specific locality data.

Conservation Issues: Until a better understanding of site specific habitat conditions is achieved

there is little on which to base speculations about long-term viability. If present conditions, whatever they are, were to remain unchanged, the currently known populations will probably persist indefinitely.



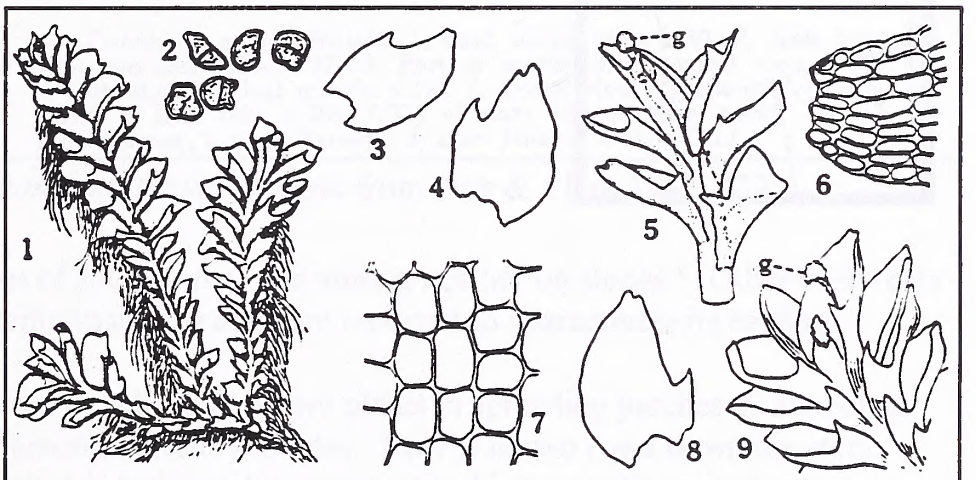
TRITOMARIA EXSECTIFORMIS (Breidl.) Loeske
forest brownwort
Recent synonyms: none.

Status: ONHP List 2; ROD Table C-3; Final SEIS Table J2-8a.

Distribution: Arctic-boreal; in Okanogan County, Washington and two Oregon sites (Head of Jack Creek, Jefferson County and Tumalo Falls, Deschutes County).

Habitat/Ecology: On peaty or humic soil, or rotting wood, often on creek banks where perpetually shady, cool and moist. Associates (at Tumalo Falls, Deschutes County) include *Lophozia incisa, Lophozia ventricosa, Blepharostoma trichophyllum, Calypogeia muelleriana, Cephalozia lunulifolia,* and *Lepidozia reptans.* Both Oregon sites are in mixed coniferous forests, at 3200' and 5100' elevations. Vascular associates are not noted in the literature except mention of occurrence in forest habitats.

Description: Small, yellowish-green to brownish-green plants with two rows of asymmetrical leaves, growing in small tufts among other liverworts and mosses. Leaves 2- to 3-lobed with the dorsal lobe slender, divergent, positioned 2/3 up the margin. Reddish-brown, angular gemmae in globular masses at the tips of the leaf lobes. Perianths rare; underleaves lacking.



Tritomaria exsectiformis. 1, Plant, dorsal view, x 9.5. 2, Five gemmae, x 286. 3-4, Leaves, x 17. 5, Tip of shoot, dorsal view, with gemmae (*g*), x 26. 6, Tip of leaf which bore gemmae, x 93. 7, Cells of the leaf middle, x 237. 8, Leaf, x 17. 9, Tip of shoot, dorsal view, with gemmae (*g*), x 31. (1-2, after K. Mueller; 3-4, 7-9, original, by Elizabeth Curtis; 5, after Buch; 6, after Jensen.)

Tritomaria exsectiformis from Frye & Clark 1945: 419.

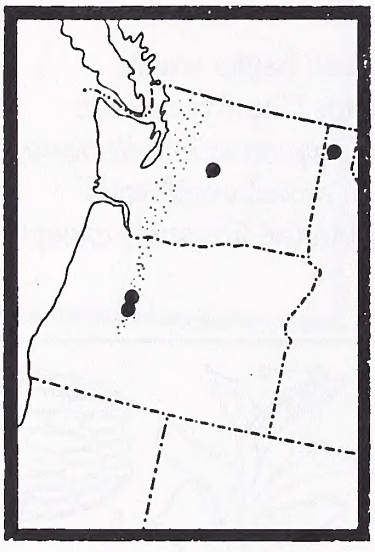
Distinctive characters: Assymmetrical, 2- to 3-lobed leaves, brownish, angular gemmae.

Similar species: Very similar to *T. exsecta*. *Tritomaria exsectformis* has angular gemmae, *T. exsecta* has ovoid gemmae. See also the Key to *Tritomaria*, Part IV.

Other descriptions and illustrations: Frye & Clark 1945: 418, *419*. Müller 1954: 738, fig. 241. Schuster 1953: 378. Schuster 1969: 653, figs. 224-226. Smith 1990: 128, fig. 55.

Notes/Comments: The Jefferson County site was recently revisited and the population of *Tritomaria exsectiformis* surveyed. It was found in scattered patches throughout the site, along with 16 other liverworts, 29 mosses, and 2 ferns under a broken *Alnus* overstory.

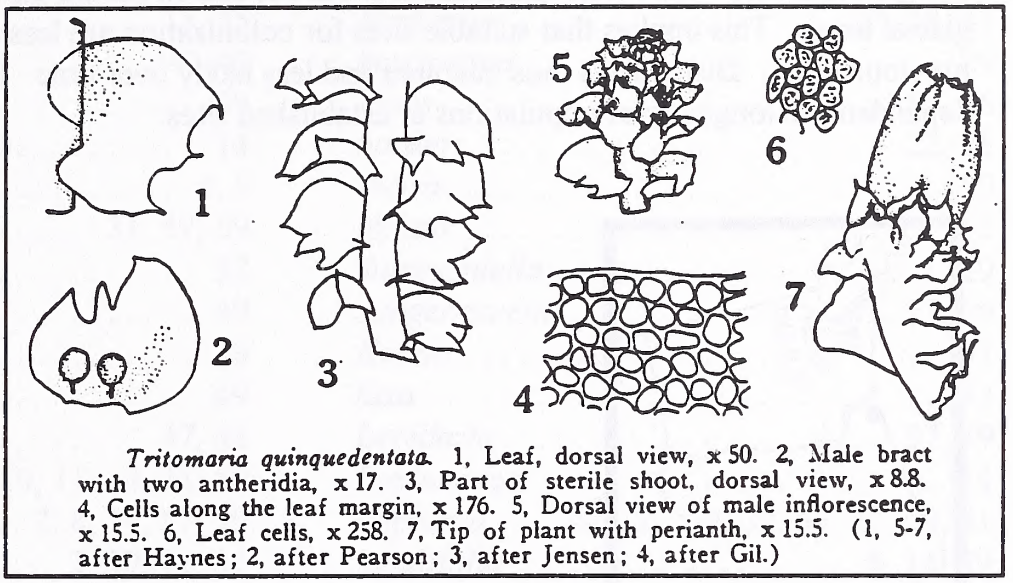
Conservation Issues: This species seems to reflect a common pattern of arctic-boreal bryophytes in the Oregon Cascades. Many of the species in this group are closely associated with permanent, cold-water streams. These sites appear to represent cool, moist refugia for plants which were more abundant in the region during glacial and immediate post-glacial times. This implies that suitable sites for colonization are less abundant now than in previous times. Dispersal is thus inhibited and less likely over time. Long term viability is dependent on longevity of populations at established sites.



TRITOMARIA QUINQUEDENTATA (Huds.) Buch
giant brownwort
Recent synonyms: none.

Status: ONHP List 3; ROD Table C-3.

Distribution: Circumboreal; western Washington, Saddle Mountain, Clatsop County, Oregon.



Tritomaria quinquedentata. 1, Leaf, dorsal view, x 50. 2, Male bract with two antheridia, x 17. 3, Part of sterile shoot, dorsal view, x 8.8. 4, Cells along the leaf margin, x 176. 5, Dorsal view of male inflorescence, x 15.5. 6, Leaf cells, x 258. 7, Tip of plant with perianth, x 15.5. (1, 5-7, after Haynes; 2, after Pearson; 3, after Jensen; 4, after Gil.)

Tritomaria quinquedentata from Frye & Clark 1945: 422.

Habitat/Ecology: Restricted to organic substrates where perpetually shady, cool and moist. According to Hong (1994), "The species occurs on wet humus over boulders, shaded cliffs, soil over exposed rock surfaces, decaying branches at the fringes of spray zones, and among heather on slopes." Other liverworts are listed as associates; no specific vascular plants are reported to characterize its habitats.

Description: Large, bright green to yellowish-brown plants in sprawling patches or ascending when shoots crowded, usually among other bryophytes. Leaves in two rows down the stem, rather consistently 3-lobed, rarely 4-lobed, notably asymmetrical because the ventral margin is much longer than the dorsal margin so the dorsal lobe is the smallest. Lobe tips acute, usually with a little point (cuspidate). Gemmae scarce, of variable form; underleaves absent.

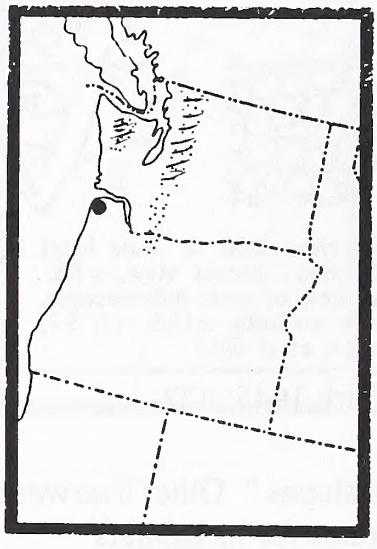
Distinctive characters: Field clues are the large size coupled with the markedly asymmetric, 3-lobed leaf.

Similar species: This species could be taken for a species of *Lophozia* subgen. *Barbilophozia*, but it has neither cilia on the ventral base of leaves nor underleaves.

Other descriptions and illustrations: Frye & Clark 1945: 421, *422*. Müller 1954: 736, fig. 240. Hong 1994. Kitagawa 1966: 117, fig. XXIV. Schuster 1969: 678, figs. 230-232. Smith 1990: 128, fig. 55.

Notes/Comments: Hong (1994) maps seven localities from western Washington for this species without citation of specific collections or site data. The first and only record of the species from Oregon is on Saddle Mountain (Schofield and Godfrey 1979).

Conservation Issues: The Oregon site on Saddle Mountain is probably secure because of its relative inaccessibility. However, any changes (such as trail location or similar action) which might cause significant disturbance to vegetation in the upper regions of the park could jeopardize portions of the rare liverwort populations. This species seems to reflect a common pattern of arctic-boreal bryophytes in the Oregon Cascades. The sites appear to represent cool, moist refugia for plants which were more abundant in the region during glacial and immediate post-glacial times. This implies that suitable sites for colonization are less abundant now than in previous times. Dispersal is thus inhibited and less likely over time. Long term viability is dependent on longevity of populations at established sites.



Index to Liverwort Names in Species Treatments

PART VI. KEYS FOR IDENTIFICATION OF MOSSES

Because so many of the taxa treated in this guide cannot be found in Lawton (1971), it is impossible to identify all of them using her keys. While the best solution would be to write new keys to accommodate all new additions to the flora, such a task was beyond the scope of this project. Instead, the following treatments show where taxa described in this guide should key out, using Lawton (1971) as a base to work from. Keys and descriptions written by other authors are listed when available, and should be used whenever possible to confirm identifications. A glossary for technical terms can be found after the individual species treatments in the next section of this guide.

Andreaea schofieldiana: Lawton 1971: page 25, Key 7 (*Andreaea*), lead 2a: would key to *A. nivalis*; insert additional lead:

2a. Plants not brittle; perichaetial bracts similar to the vegetative leaves . . . . . 2a[1]
2a[1]. Leaves papillose; leaf margins usually distinctly serrate; spores 17-25μm . . . . . A. NIVALIS
2a[1]. Leaves without papillae; leaf margins usually entire or finely crenate; spores 20-30(36) μm . . . . . A. SCHOFIELDIANA

Other keys and descriptions: Murray 1987: page 25 (Key to costate *Andreaea* of North America and Europe).

Antitrichia curtipendula: Lawton 1971: page 240, Key 83 (*Antitrichia*).

Bartramiopsis lescurii: Lawton 1971: page 30, Key 11 (Polytrichaceae).

Brotherella roellii: Lawton 1971: page 18, Key 4 (Pleurocarpous mosses, the leaves ecostate, or the costa short, double, or both); page 320, Key 114 (Hypnaceae).

Bruchia bolanderi: Lawton 1971: page 11, Key 1 (Introductory Key), lead 55a; would key to *Voitia nivalis*; insert additional leads:

55a. Capsule 2-4 mm long, seta long . . . . . 55a[1]
55a[1]. Plants 1-6 cm tall, stems clothed in rhizoids; leaves ovate-lanceolate, with an excurrent costa; seta strongly twisted just below capsule; capsules widest at bottom, tapering to an oblique point; arctic-alpine . . . . . VOITIA NIVALIS
55a[1]. Plants 5-12 mm tall, stems without rhizoids; leaves linear, without an excurrent costa; seta straight; capsules widest in the upper half . . . . . BRUCHIA (55a[2])
55a[2]. Seta straight, 1.6-5.4 mm long, usually longer than 3 mm; spores warty; montane to subalpine . . . . . BRUCHIA BOLANDERI
55a[2]. Seta curved, 0.5-3.0 mm long, averaging 1.2 mm; spores spinose; low elevation

interior valleys . . . . . BRUCHIA FLEXUOSA

Other keys and descriptions: Rushing 1986: page 49 (Key to species of *Bruchia*).

Buxbaumia piperi: Lawton 1971: page 29, Key 10 (*Buxbaumia*).

Buxbaumia viridis: Lawton 1971: page 29, Key 10 (*Buxbaumia*).

Calliergon trifarium: Lawton 1971: page 269, Key 98 (*Calliergon*).

Campylopus schmidii: page 62, Key 25 (*Campylopus*); replace key with:

1a. At least some leaves with hyaline awns or projecting costae 2
1b. Leaves without hyaline awns or projecting costae 4
2a. Cells of leaf blade oval or short rectangular, the walls smooth; awns 1-3 mm long, curved at a 90° angle when dry, forming conspicuous tufts at tip of shoots . . . . . C. INTROFLEXUS
2b. Cells of leaf blade ± elongate, sinuose, the walls pitted; awns not curved at a 90° angle, not forming conspicuous tufts 3
3a. Basal cells of leaf blade thick-walled; costa ribbed at back; rhizoids smooth; plants dark green or blackish; on wet peat or rocks . . . . . C. ATROVIRENS
3b. Basal cells of leaf blade thin-walled; costa smooth at back; rhizoids minutely papillose; plants usually golden yellow, sometimes blackish; on sand . . C. SCHMIDII
4a. Basal cells of leaf blade thick-walled . . . . . C. FLEXUOSUS
4b. Basal cells of leaf blade thin-walled 5
5a. Cells of leaf blade nearly square; tips of shoots and leaves deciduous, breaking off to serve as asexual propagules . . . . . C. FRAGILIS
5b. Cells of leaf blade rectangular; plants without deciduous parts . . . . . C. SCHIMPERI

Other keys and descriptions: Frahm 1980: 571 (Key to taxa of *Campylopus* in North America, north of Mexico).

Conostomum tetragonum: Lawton 1971: page 15, Key 3 (Acrocarpous mosses with smooth leaf cells); page 206, Key 70 (Bartramiaceae).

Crumia latifolia: Lawton 1971, all as "*Scopelophila latifolia*": page 11, Key 1 (Introductory Key); page 84, Key 35 (Pottioideae); page 85, Key 37 (Pottiaceae).

Encalypta brevicolla var. ***crumiana***: Lawton 1971: page 115, Key 47 (*Encalypta*); replace key with:

1a. Uppermost leaves with awns 2
1b. Uppermost leaves without awns 9
2a. Peristome present 3

2b. Peristome absent 7
3a. Mature capsules ribbed longitudinally 4
3b. Mature capsules smooth, wrinkled or slightly striate 5
4a. Base of calyptra fringed into distinct segments; leaf margins recurved; brown filamentous propagulae often present among upper leaves . . . . . E. PROCERA
4b. Base of calyptra entire or erose; leaf margins plane; propagulae absent . . . . . E. RHAPTOCARPA
5a. Peristome teeth red . . . . . E. LONGICOLLA
5b. Peristome teeth white or peach-colored 6
6a. Peristome teeth papillose, white, well-developed; beak of calyptra about ⅓ length of calyptra; spores with prominent papillae . . . . . E. BREVICOLLA var. BREVICOLLA
6b. Peristome teeth smooth, peach-colored, poorly-developed; beak of calyptra about ¼ length of calyptra; spores weakly ornamented . . . . . E. BREVICOLLA var. CRUMIANA
7a. Leaves oblong-lanceolate, tapering gradually to a narrowly acute apex, the awn short and yellow . . . . . E. ALPINA
7b. Leaves oblong or ovate, rounded at tip except for awn 8
8a. Mature capsules smooth, wrinkled or slightly striate . . . . . E. BREVIPES
8b. Mature capsules longitudinally ribbed . . . . . E. SPATHULATA
9a. Peristome present 10
9b. Peristome absent 11
10a. Peristome teeth pink . . . . . E. AFFINIS var. MACOUNII
10b. Peristome teeth dark orange . . . . . E. CILIATA
11a. Base of calyptra fringed into distinct segments; capsules ribbed longitudinally; leaves recurved below; plants small, to 9 mm tall . . . . . E. MUTICA
11b. Base of calyptra entire or erose 12
12a. Mature capsules ribbed longitudinally . . . . . E. INTERMEDIA
12b. Mature capsules smooth, wrinkled or slightly striate . . . . . E. VULGARIS

Other keys and descriptions: Horton 1983: 376 (Key to species of *Encalypta*).

Encalypta brevipes: Lawton 1971: page 115, Key 47 (*Encalypta*); use new key as given above.

Funaria muhlenbergii: Lawton 1971: page 152, Key 54 (*Funaria*).

Helodium blandowii: Lawton 1971: page 260, Key 92 (Thuidiaceae).

Iwatsukiella leucotricha: Lawton 1971: page 18, Key 4 (Pleurocarpous mosses, the leaves ecostate, or the costa short, double, or both); would key to couplet 30; insert additional lead:

30a[1]. Plants on tree trunks . . . . . IWATSUKIELLA LEUCOTRICHA

Limbella fryei: Lawton 1971, all as "*Sciaromium tricostatum*": page 21, Key 5 (Pleurocarpous

mosses with unicostate leaves, the costa to the middle of the leaf or longer); page 265, Key 96 (Amblystegiaceae).

Orthodontium gracile: Lawton 1971: page 13, Key 1 (Introductory Key); page 162, Key 61 (Bryaceae).

Pleuroziopsis ruthenica: Lawton 1971: page 21, Key 5 (Pleurocarpous mosses with unicostate leaves, the costa to the middle of the leaf or longer).

Pohlia sphagnicola: Lawton 1971: page 179, Key 64 (*Pohlia*); would key to couplet 20; insert additional lead:

20a[1]. Gemmae absent; leaves nearly entire, cells thick-walled; on sphagnum hummocks in bogs . . . . . P. SPHAGNICOLA

Lawton's key to *Pohlia* needs to be rewritten completely to accommodate more species.

Other keys and descriptions: Shaw 1982: 222 (Key to sterile *Pohlia*).

Polytrichum sphaerothecium: Lawton 1971: page 39, Key 15 (*Polytrichum*), lead 4a; would key to *P. sexangulare*; insert additional lead:

4a. Leaves blunt and ± cucullate at the apex . . . . . 4a[1]
4a[1]. Mature capsules usually with 6 longitudinal ridges; capsules exserted well beyond leaves, on straight setae; on moist or peaty soil at high elevation . . . . . P. SEXANGULARE
4b[1]. Mature capsules wrinkled but not angled, barely exserted beyond leaves, on curved setae; on rock at high elevation . . . . . P. SPHAEROTHECIUM

Polytrichum strictum: Lawton 1971: page 39, Key 15 (*Polytrichum*).

Racomitrium aquaticum: Lawton 1971, all as *Rhacomitrium*: page 141, Key 50 (*Racomitrium*).

Racomitrium pacificum: Lawton 1971, all as "*Rhacomitrium*": page 141, Key 50 (*Racomitrium*), lead 7a; would key to *R. heterostichum* var. *heterostichum*; insert additional lead:

7a. Leaf cells not papillose . . . . . 7a[1]
7a[1]. Plants a dirty, olive green; cross walls of leaf cells thickened and bulging on both sides of leaf; leaf blades sometimes with bistratose regions . . . . . R. HETEROSTICHUM and segregate taxa
7a[1]. Plants green to yellow green; cross walls not bulging; leaf blades unistratose . . . . . R. PACIFICUM

Lawton's key to *Racomitrium* needs to be rewritten completely to accommodate more species.

Other keys and descriptions: Frisvoll 1988: 40 (Key to North and Central American taxa of *Racomitrium heterostichum* sect. *Laevifolia*); Frisvoll 1988: 98 (Key to the taxa in the *Racomitrium heterostichum* subgroup).

Rhizomnium nudum: Lawton 1971: page 189, Key 66 (Species of Mniaceae).

Rhytidium rugosum: Lawton 1971: page 21, Key 5 (Pleurocarpous mosses with unicostate leaves, the costa to the middle of the leaf or longer); page 329, Key 116 (Rhytidiaceae)

Schistostega pennata: Lawton 1971: page 9, Key 1 (Introductory Key).

Scouleria marginata: Lawton 1971: page 149, Key 51 (*Scouleria*).

Splachnum ampullaceum: Lawton 1971: page 157, Key 57 (Splachnaceae).

Tayloria serrata: Lawton 1971: page 157, Key 57 (Splachnaceae).

Tetraphis geniculata: Lawton 1971: page 27, Key 8 (Tetraphidaceae).

Tetraplodon mnioides: Lawton 1971: page 157, Key 57 (Splachnaceae).

Trematodon boasii: Lawton 1971: page 9, Key 1 (Introductory Key); page 83, Key 33 (*Trematodon*).

Tripterocladium leucocladulum: Lawton 1971: page 18, Key 4 (Pleurocarpous mosses, the leaves ecostate, or the costa short, double, or both); page 320, Key 114 (Hypnaceae).

Triquetrella californica: Lawton 1971: This species cannot be identified using Lawton's keys, because when she gets close to where *Triquetrella* would key, she relies on characters of the sporophyte, and capsules have never been found in *T. californica*. The closest match would be on page 85, Key 37 (Pottiaceae), lead 11a; insert:

11a. Leaves lanceolate, ovate or ovate-lanceolate; capsule apiculate, without an operculum, or capsules unknown . . . . . 11a[1]

11a[1]. Leaves ovate to ovate-lanceolate, concave, clustered like a clove of garlic, surrounding a tiny immersed capsule; the costa excurrent as an awn; capsule apiculate, without an operculum; minute plants on disturbed soil . . . . . PHASCUM CUSPIDATUM

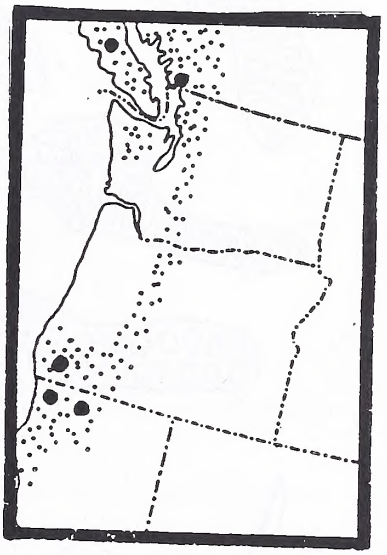
11a[1]. Leaves lanceolate, the costa ending at the apex; leaves imbricate when dry, erect-spreading to squarrose when wet, spiraling up the stem in three longitudinal rows; capsules unknown; larger plants on soil and rock . . . . . .

. . . . . TRIQUETRELLA CALIFORNICA

Ulota megalospora: Lawton 1971: page 228, Key 77 (*Ulota*).

PART VII. SPECIES TREATMENTS: MOSSES

ANDREAEA SCHOFIELDIANA B. Murr.
Broad-leaved lantern moss, Schofield's black moss
Recent synonyms: None



Status: SAT Appendix 5-H; ONHP List 2.

Distribution: Endemic to the Pacific Northwest. Southwestern British Columbia to Siskiyou and Del Norte counties, California.

Habitat and ecology: Forming mats on dry and exposed to moist, shaded igneous rocks, montane to subalpine. Associated species include rock garden genera such as *Saxifraga, Sedum, Selaginella*, the liverwort *Gymnomitrion,* crustose lichens and *Cladonia.*

Description: Plants erect, rarely over 1 cm tall, dark reddish-brown to blackish. Leaves lanceolate, 2-2.5 mm long, costate, imbricate when dry, sometimes falcate at tip of shoot, broad enough at back to show a portion the blade on each side of the well-defined costa. Leaf margins entire, or finely crenate toward tips because of projecting cells. Leaf cells without papillae, the basal laminal cells squarish, round or rectangular near costa or margins, the walls pitted and sinuose. Capsules opening by four vertical valves, the urn shrinking vertically when dry, to resemble a Japanese lantern. Spores 20-30(36) μm.

Distinctive characters: A combination of (1) tiny brown or blackish plants growing on rocks, with (2) capsules opening by four vertical valves, the urn shrinking vertically when dry to resemble a Japanese lantern, will put you in the genus *Andreaea*. *A. schofieldiana* has (1) flattened leaves with blades visible on either side of well-defined costa, (2) cells without papillae, and (3) spores 20-30(36) μm.

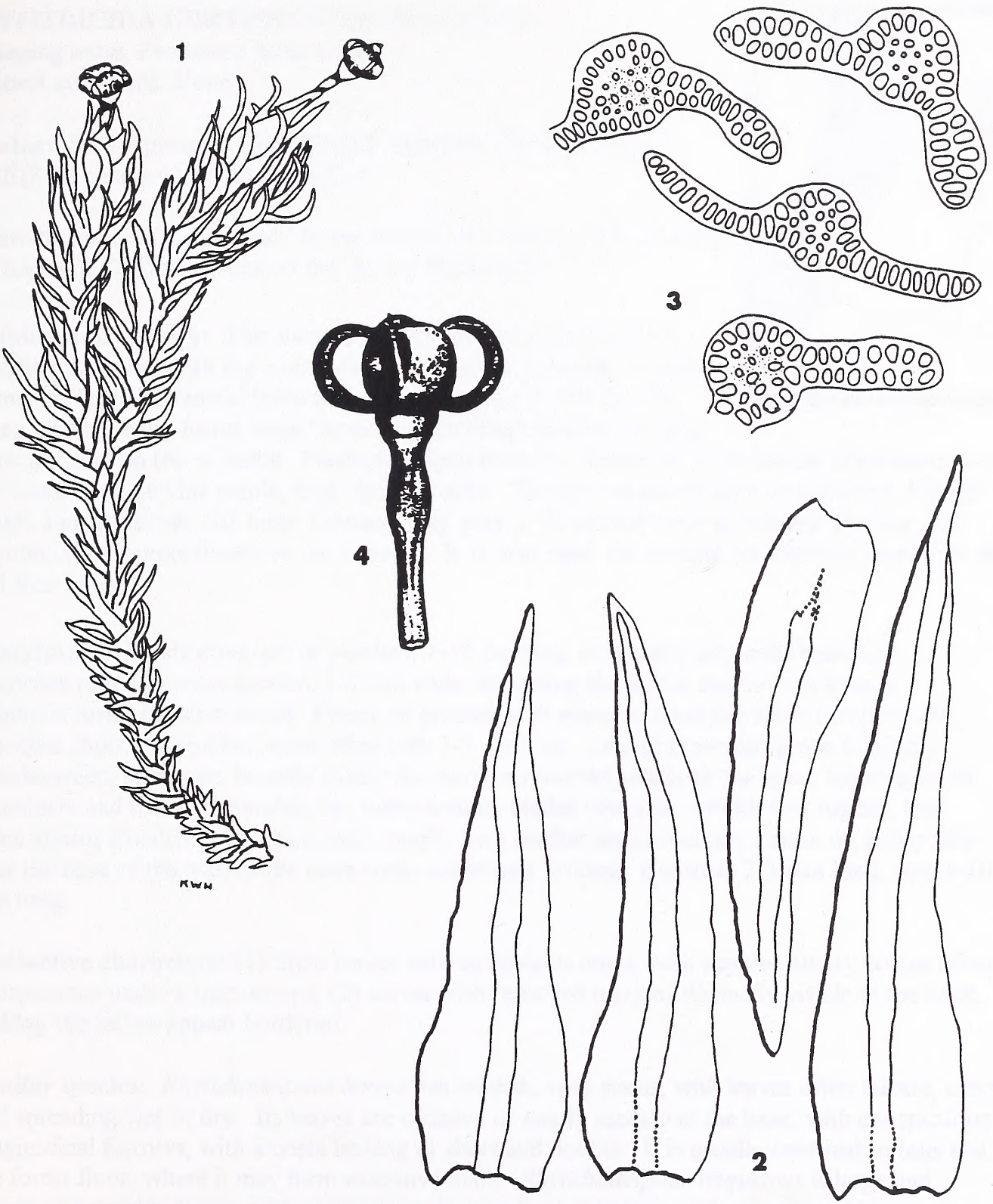
Similar species: *Andreaea nivalis* is the only other species with a relatively broad and flat leaf blade, with a conspicuous costa, that can be seen with a hand lens. It has papillose cells and toothed leaf margins, while *A. schofieldiana* has smooth cells and entire or crenate leaf margins.

Other descriptions and illustrations: Murray 1987: 16.

Notes and comments: Murray (1987) revised material from most regional herbaria, and a paucity of collections suggests it is a rare species. Most populations probably occur on federal land.

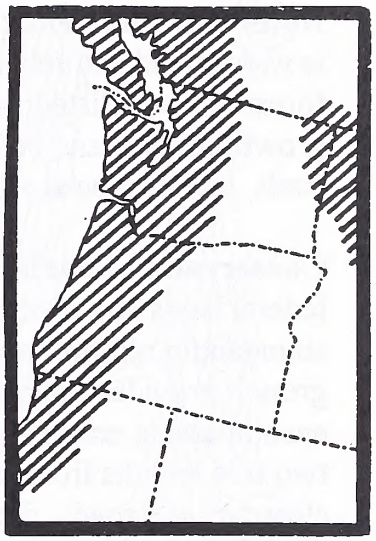
Conservation issues: Habitats of known populations need to be characterized, to help locate new sites and determine the species' distribution and abundance. Quarrying and construction of roads, hiking and ski trails could decimate populations locally by destroying rock substrate or

coating rocks with dust. Logging could impact populations in shaded, moist microclimates by removal of canopy shade, increased insolation, and disruption of surface runoff.



Andreaea schofieldiana. -- 1. Plant with capsules. -- 2. Leaves. -- 3. Cross-sections of leaves. -- 4. Capsule, with distinctive vertical valves. From Flowers (1973), and Murray (1987). Reprinted with permission of Brigham Young University Press, and the American Bryological and Lichenological Society.

ANTITRICHIA CURTIPENDULA (Hedw.) Brid.
Hanging moss, Pendulous wing moss
Recent synonyms: None



Status: SAT Appendix 5-H; FEMAT Appendix Table IV-A-3; FSEIS Appendix J2; ROD Table C-3.

Distribution: Circumboreal. In the Pacific Northwest, from Alaska to northern California, east to the Rocky Mountains.

Habitat and ecology: This moss is best developed in cool, moist coniferous forests with fog penetration and cold air drainage, where it grows on large horizontal limbs in the lower canopy of old-growth trees. It frequently forms large "sleeves" encircling branches, or large mats perched on top of limbs. Plants dislodged from the canopy by wind storms often survive in the understory on vine maple, logs, duff or rocks. The species also occurs on red alder, bigleaf maple and white oak. Its large biomass may play a "keystone" role in mineral cycling and regulation of microclimate in the canopy. It is also used for nesting by marbled murrelets and red tree voles.

Description: Plants prostrate or pendant, 1-15 cm long, irregularly pinnately branched. Branches round in cross-section, 2-3 mm wide, becoming threadlike and 2-3 cm long in epiphytic forms in moist forest. Plants on ground or in exposed areas are more compact, the branches short and stubby, stems often only 1-3 cm long. Leaves brownish-green to glossy yellow-green, imbricate, broadly ovate, the margins recurved nearly to the apex, tapering to an acuminate and usually spreading tip, many secund, blades variously wrinkled or rugose, but often almost smooth. Leaves costate, usually with smaller supplementary costae on either side near the base of the leaf, or the main costa sometimes forking. Capsules 2-3 mm long, seta 6-10 mm long.

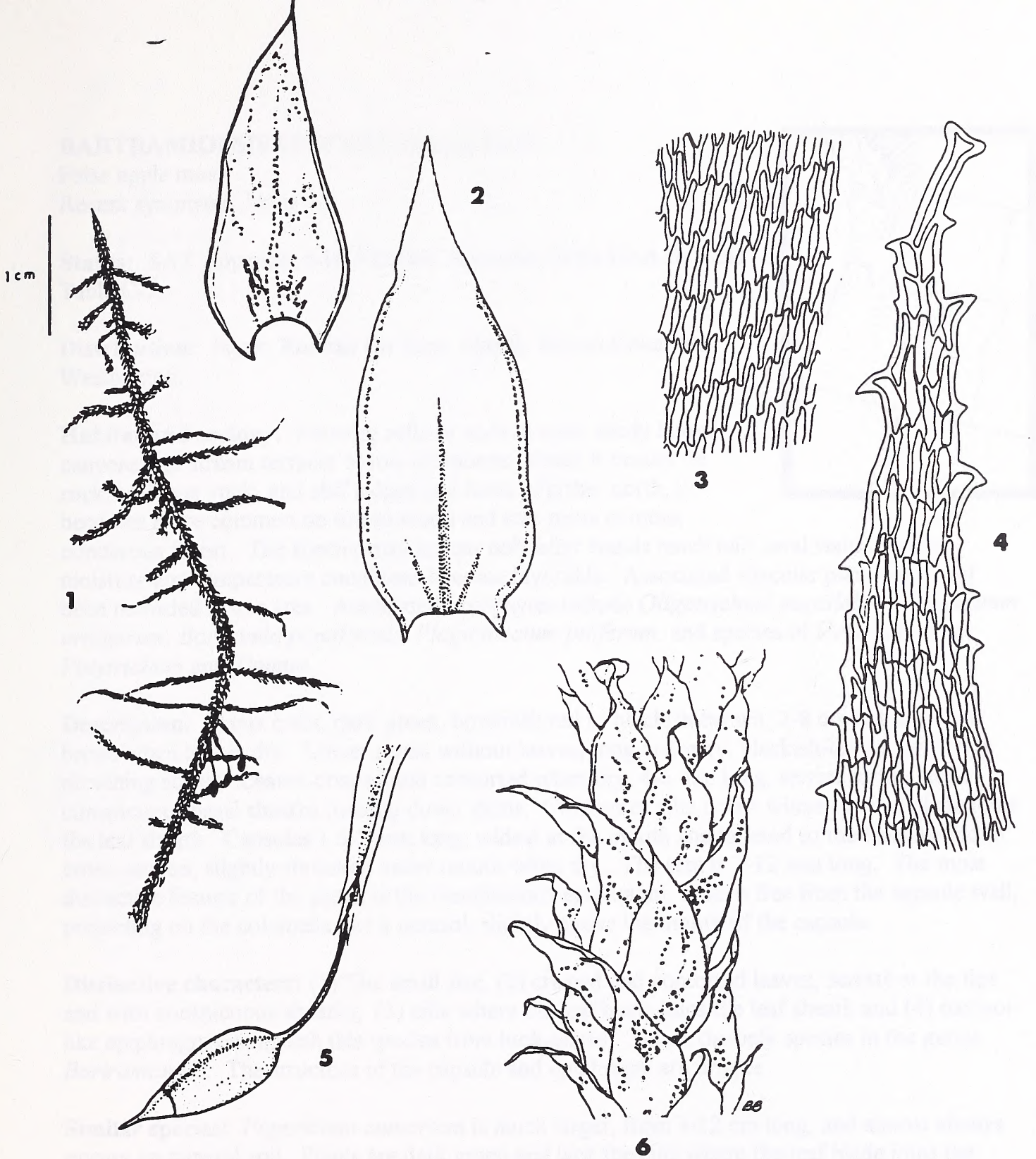
Distinctive characters: (1) Stem leaves with an obvious costa, with supplementary costae often conspicuous under a microscope, (2) leaves with recurved margins distinctly visible at the back, making the leaves appear bordered.

Similar species: *Rhytidiadelphus loreus* has reddish, wiry stems, with leaves often falcate, erect and spreading wet or dry. Its leaves are concave or nearly saccate at the base, with conspicuous longitudinal furrows, with a costa lacking or short and double. It is usually confined to logs and the forest floor, where it may form extensive mats. *Rhytidiadelphus triquetrus* is large and shaggy, its wrinkly leaves with conspicuous longitudinal striations, and no recurved margins. The costa is double.

Other descriptions and illustrations: Grout 1934: 224, *Pl. 70B*; Nyholm 1960: 375; Lawton 1971: 240, *Pl. 131*; Harthill & O'Connor 1975: 39; Crum and Anderson 1981: 768, 769; Vitt et al. 1988: 114; Schofield 1992: 64, *65*; Pojar and MacKinnon 1994: 465.

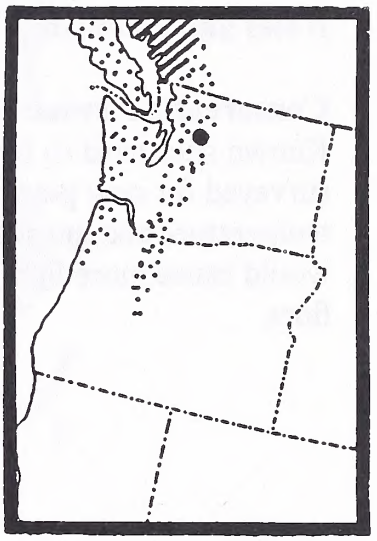
Notes and comments: *Antitrichia curtipendula* is one of our more robust epiphytic mosses. It is widespread and relatively common throughout the region, in both coniferous and hardwood forests. It was listed as sensitive because of its suspected "keystone" role in the canopy of old-growth forests, and because about 25 percent of the populations in our area occur on non-federal lands, and may be at risk there because of habitat loss and air pollution. .

Conservation issues: Loss of 25 percent of populations of *Antitrichia curtipendula* on non-federal lands could elevate its status on federal lands. Norris (1987) reported that it was more abundant in old-growth redwood forest than in 100-year-old second-growth, indicating that old-growth provides optimal habitat for the species. *A. curtipendula* needs broad riparian buffers, encompassing entire stream terraces, as much of the biomass of this species exists beyond one or two tree lengths from streams. On many stream terraces, old-growth has been fragmented by clearcuts and roads, decimating populations of *A. curtipendula*. It is important to preserve shading and moisture retention in the canopy, to promote the growth of this species. Thinning or harvest on stream terraces will desiccate stands and may cause a decline in bryophyte biomass. Protection of existing populations will enable dispersal to developing late-successional or old-growth stands elsewhere in the landscape. The species is declining from air pollution in Scandinavia and Europe (Hallingbäck 1992). Its location on stream bottoms in the Pacific Northwest makes it vulnerable to air pollution, because aerosols tend to concentrate in valleys.



Antitrichia curtipendula. -- 1. Plant with capsules. -- 2. Leaves, showing forked costa. -- 3. Cells in middle of leaf. -- 4. Cells at tip of leaf. -- 5. Capsule. -- 6. Detail of shoot, showing wrinkled leaves. From Lawton (1971), Crum and Anderson (1981) and Schofield (1992). Reprinted with permission of the Hattori Botanical Laboratory, Columbia University Press, the Royal British Columbia Museum, and Wilfred B. Schofield.

BARTRAMIOPSIS LESCURII (James) Kindb.
False apple moss
Recent synonyms: None



Status: SAT Appendix 5-H; FEMAT Appendix Table IV-A-3; ROD Table C-3.

Distribution: Japan, Russian Far East, Alaska, British Columbia, Washington.

Habitat and ecology: Forming tufts or sods in cool, shady humid canyons and stream terraces at low elevations, where it occurs on rock, soil over rock, and cliff ledges and faces. Farther north, it becomes more common on rotten wood and tree roots in moist coniferous forest. The species may appear only after stands reach mid-seral status, when moisture and temperature conditions become favorable. Associated vascular plants have not been recorded in our area. Associated bryophytes include *Oligotrichum parallelum, Pogonatum urnigerum, Bartramia pomiformis, Plagiothecium piliferum,* and species of *Heterocladium, Polytrichum* and *Timmia*.

Description: Plants erect, dark green, brownish red to blackish-brown, 2-8 cm tall, 2-4 mm broad when leaves dry. Lower stems without leaves, long and wiry, blackish-brown, with tiny sheathing scales. Leaves crisped and contorted when dry, 4-6 mm long, serrate at tips, with conspicuous basal sheaths running down stems. Clusters of cilia occur where the leaf blade joins the leaf sheath. Capsules 1.5-2 mm long, widest at the mouth and tapered to the base, round in cross-section, slightly shrunken under mouth when dry. The seta is 7-12 mm long. The most distinctive feature of the genus is the membranous epiphragm, broken free from the capsule wall, projecting on the columella like a parasol, slightly above the mouth of the capsule.

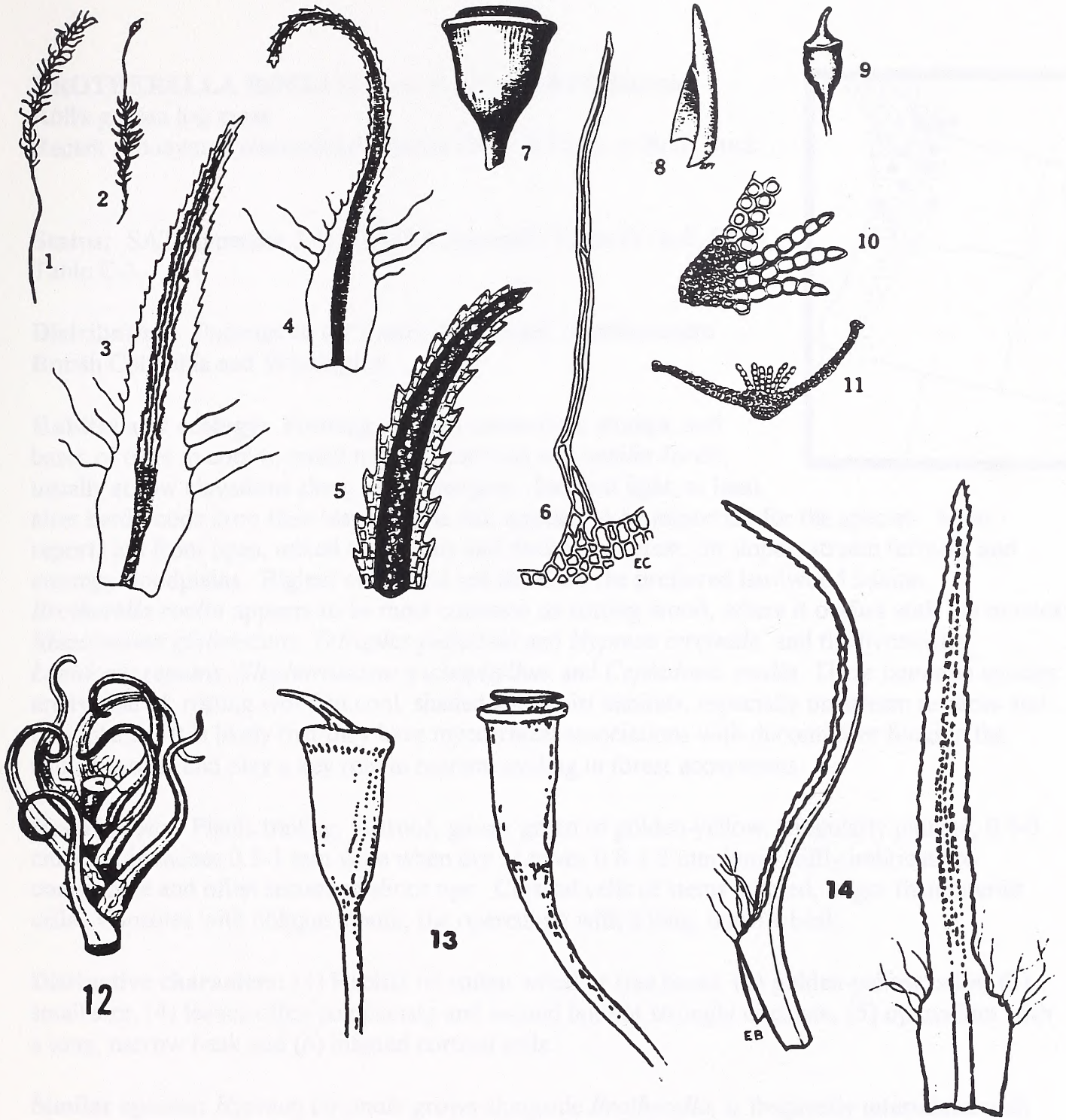
Distinctive characters: (1) The small size, (2) crisped and contorted leaves, serrate at the tips and with conspicuous sheaths, (3) cilia where the leaf blade joins the leaf sheath and (4) parasol-like epiphragm distinguish this species from look-alikes. This is the only species in the genus *Bartramiopsis*. The structure of the capsule and epiphragm are unique.

Similar species: *Pogonatum contortum* is much larger, from 3-12 cm long, and almost always occurs on mineral soil. Plants are dark green and lack the cilia where the leaf blade joins the sheath. The dry capsules lack the parasol-like epiphragm, are strongly shrunken under the mouth, are 2-3.5 mm long, and the seta is 3-5.5 cm long. *Timmia* species have lighter-colored leaves, because they are unistratose, and lack the lamellae of *Bartramiopsis* and its relatives. The lower stems are often clothed in reddish-brown or white rhizoids, and there are no cilia where the leaf blade joins the leaf sheath.

Other descriptions and illustrations: Brotherus 1909: 678; Frye 1910: 291; Frye 1937: 112, *Pl. 57A*; Lawton 1971: 33, *Pl. 6*; Schofield 1985: 58.

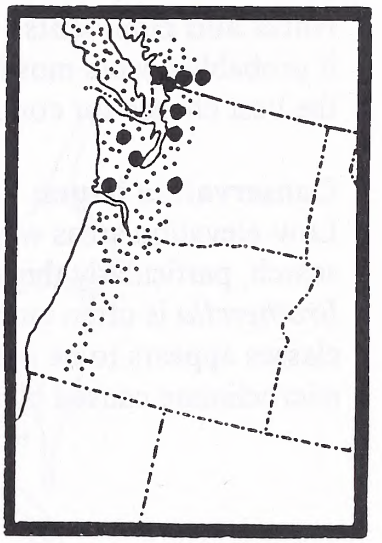
Notes and comments: *Bartramiopsis lescurii* is very rare south of the Canadian border.

Conservation issues: Major threats would be roadbuilding, logging and overcollecting. Known sites need to be searched to reconfirm presence of populations, and suitable habitat surveyed for new populations. Activities that open up the canopy could disrupt optimal temperature and moisture regimes, and have a detrimental effect on this species. Exposure would cause more light and drought-tolerant species to move in and displace the shade-tolerant flora.



Bartramiopsis lescurii. -- 1, 2. Plants with capsules, those in upper left about natural size. -- 3, 4, 14. Leaves, showing cilia at base of leaf blade. -- 5. Cells at tip of leaf. -- 6. Cells of cilia at base of leaf. -- 7, 9, 13. Capsules, with and without operculum, 13 showing exserted epiphragm projecting above edge of capsule. -- 8. Calyptra. -- 10, 11. Cross section of leaf, showing lamellae. -- 12. Detail of shoot, showing leaf configuration when dry, and cilia at bases of leaves. From Brotherus (1909), Frye (1937), and Lawton (1971). Figures from Lawton (1971) reprinted with permission of the Hattori Botanical Laboratory.

BROTHERELLA ROELLII (Ren. & Card. *in* Röll) Fleisch.
Röll's golden log moss
Recent synonym: *Pylaisiadelpha roellii* (Ren. & Card. *in* Röll) Buck



Status: SAT Appendix 5-H; FEMAT Appendix Table IV-A-3; ROD Table C-3.

Distribution: Endemic to the Pacific Northwest. Southwestern British Columbia and Washington.

Habitat and ecology: Forming mats on rotten logs, stumps, and bases of trees in cool to moist mixed deciduous and conifer forest, usually at low elevations along valley margins. Incident light, at least after hardwoods drop their leaves in the fall, appears to be important for the species. Most reports are from open, mixed coniferous and deciduous forest, on slopes, stream terraces and swampy floodplains. Bigleaf maple and red alder are the preferred hardwood habitat. *Brotherella roellii* appears to be most common on rotting wood, where it occurs with the mosses *Rhizomnium glabrescens, Tetraphis pellucida* and *Hypnum circinale,* and the liverworts *Lepidozia reptans, Blepharostoma trichophyllum* and *Cephalozia media*. These common species are typical of rotting wood in cool, shaded and moist habitats, especially on stream terraces and floodplains. It is likely that they have mycorrhizal associations with decomposer fungi in the rotting wood, and play a key role in nutrient cycling in forest ecosystems.

Description: Plants trailing, lustrous, glossy green to golden-yellow, irregularly pinnate, 0.5-3 cm long, branches 0.5-1 mm wide when dry. Leaves 0.8-1.2 mm long, stiffly imbricate to complanate and often secund at shoot tips. Cortical cells of stems inflated, larger than interior cells. Capsules with oblique mouth, the operculum with a long, narrow beak.

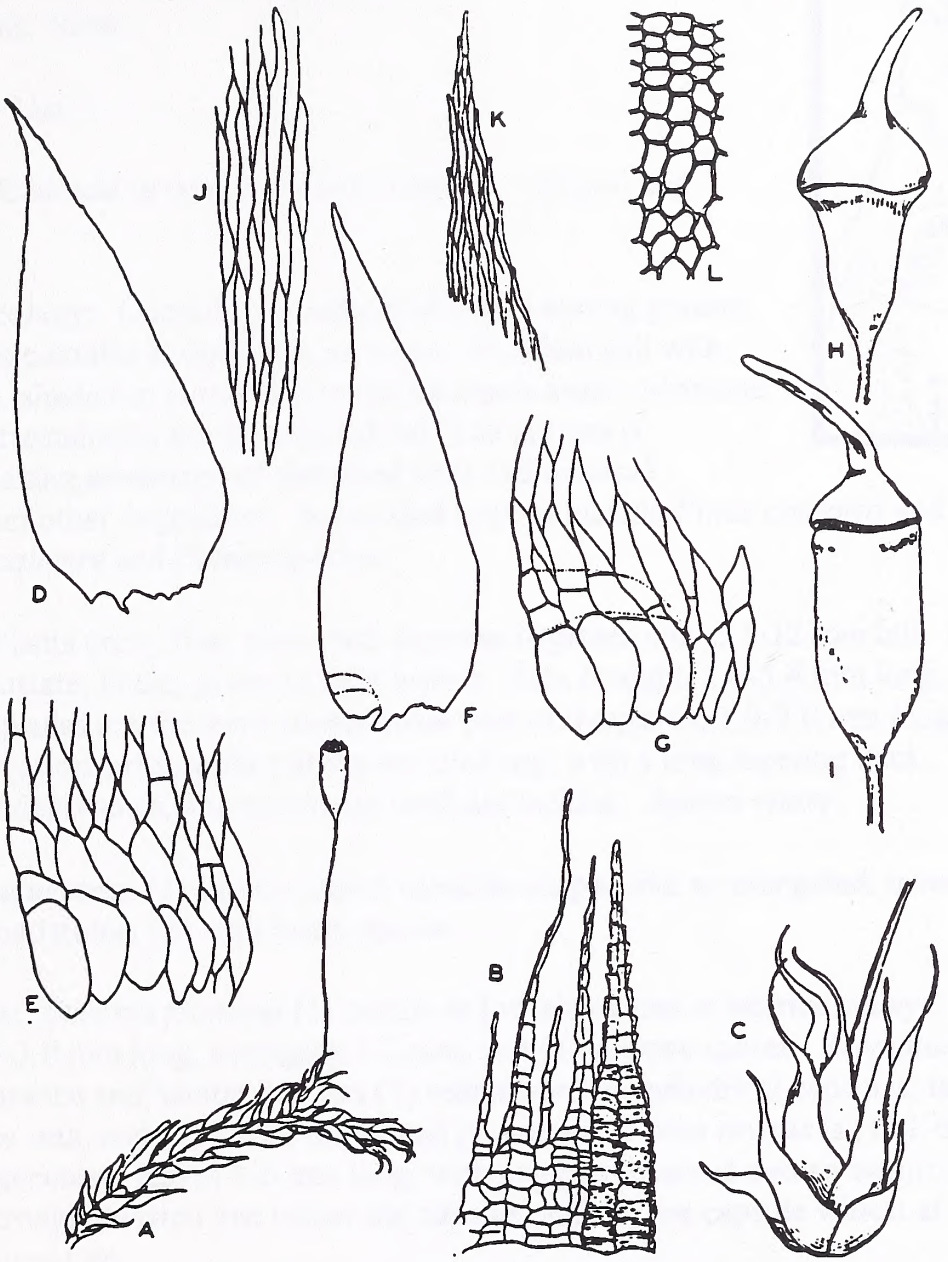
Distinctive characters: (1) Habitat on rotten wood or tree bases, (2) golden-yellow color, (3) small size, (4) leaves often complanate and secund but not strongly circinate, (5) operculum with a long, narrow beak and (6) inflated cortical cells.

Similar species: *Hypnum circinale* grows alongside *Brotherella,* is frequently intermixed with it, and is difficult to differentiate macroscopically. *Hypnum* is slightly larger, and although it is glossy, it lacks the golden luster of *Brotherella*, having instead a somewhat duller grayish-translucent appearance. The leaves of *Hypnum* are longer (1.5-2.2 mm), more linear, and are usually much more falcate or circinate than those of *Brotherella*. The capsule in *Hypnum* is horizontal or pendant, with a broad, bluntly conical operculum, while that of *Brotherella* is more erect, with a narrow, long-beaked operculum. Microscopically, the cortical cells of the stems are small and thick-walled in *Hypnum circinale*, and inflated in *Brotherella.*

Other descriptions and illustrations: Grout 1932: 137; Conard 1944: 194, *195*; Lawton 1971: 321, *Pl. 187.*

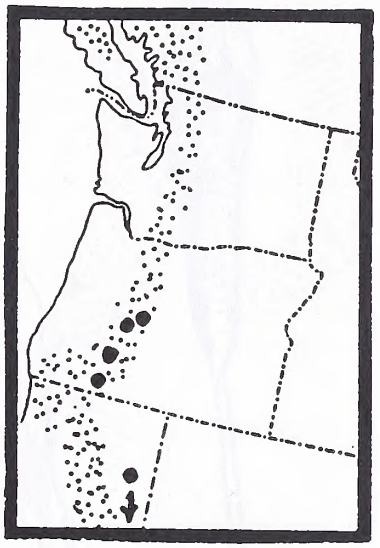
Notes and comments: This appears to be a rare species south of the Canadian border. Because it probably occurs mostly on private lands at lower elevations, protection on federal lands offers the best chance for continued viability.

Conservation issues: Known sites should be searched to reconfirm presence of populations. Low-elevation areas with abundant rotting wood and deciduous trees would be prime areas to search, particularly those with logs and stumps populated by *Hypnum circinale*, with which *Brotherella* is often intermixed. A mixture of conifers and deciduous species in different age classes appears to be preferred. Species in this habitat are sensitive to changes in light level and microclimate caused by removal or thinning of the canopy, and loss of woody debris.



Brotherella roellii. -- A. Plant and capsule without operculum. -- B. Peristome. -- C. Perichaetium. -- D, F. Leaves. -- E, G. Alar cells at base of leaves. -- H, I. Capsules, immature and mature, with operculum. -- J. Cells in middle of leaf. -- K. Cells at tip of leaf. -- L. Cells of capsule, just below mouth. From Conard (1944). Reprinted with permission of the American Bryological and Lichenological Society.

BRUCHIA BOLANDERI Lesq.
Bolander's candle moss, Bolander's pygmy moss
Recent synonyms: None



Status: ONHP List 3.

Distribution: Endemic to western North America. Oregon and California.

Habitat and ecology: Occurring as individual plants among grasses, or forming large colonies in openings, on moist, disturbed soil with organic content, shaded to partial sun in the subalpine zone. Montane meadows and streambanks are favored habitat. The species is opportunistic, taking advantage of disturbed sites and minimal competition from other vegetation. Associated species include *Pinus contorta* and the mosses *Aulacomnium palustre* and *Pohlia* species.

Description: Plants erect, tiny, stems and capsules together only 5.1-12 mm tall. Leaves 1.1-2.8 mm long, costate, linear, green to light brown. Seta straight, 1.6-5.4 mm long, usually longer than 3 mm. Capsules are the most conspicuous part of the plants, 1.9-3.0 mm long, light brown, beige to grayish at maturity, widest at the rounded top, with a long tapering neck. There is no obvious area of dehiscence, and peristome teeth are lacking. Spores warty.

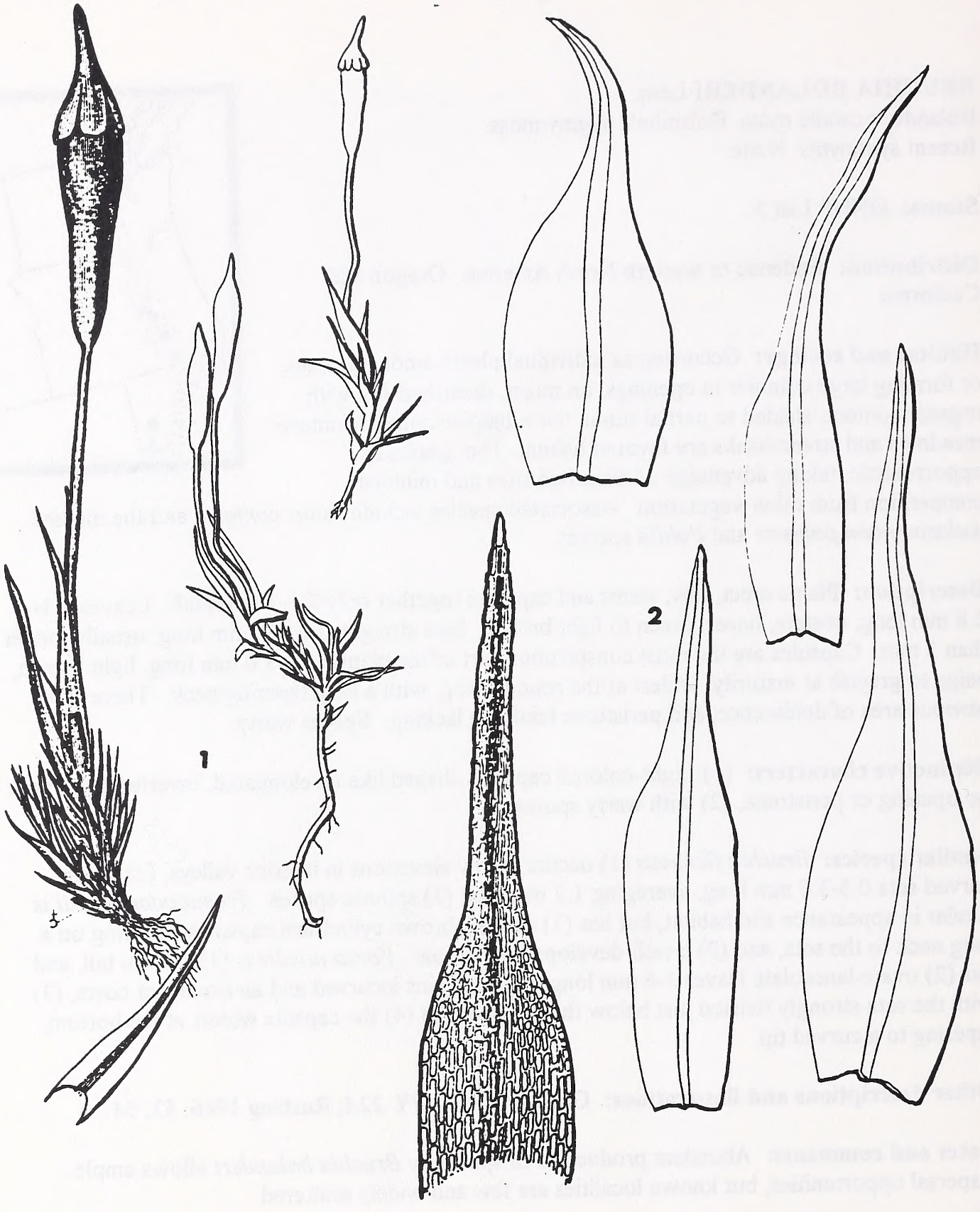
Distinctive characters: (1) Light-colored capsules shaped like an elongated, inverted pear, with no opening or peristome, (2) with warty spores.

Similar species: *Bruchia flexuosa* (1) occurs at low elevations in interior valleys, (2) has a curved seta 0.5-3.0 mm long, averaging 1.2 mm, and (3) spinose spores. *Trematodon boasii* is similar in appearance and habitat, but has (1) reddish-brown cylindrical capsules, tapering on a long neck to the seta, and (2) a well-developed peristome. *Voitia nivalis* is (1) 1-6 cm tall, and has (2) ovate-lanceolate leaves 3-6 mm long, with margins incurved and an excurrent costa, (3) with the seta strongly twisted just below the capsule, and (4) the capsule widest at the bottom, tapering to a curved tip.

Other descriptions and illustrations: Grout 1936: 37, *Pl. 22A*; Rushing 1986: 53, 54.

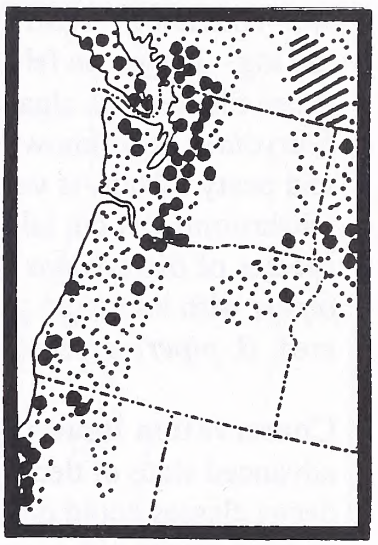
Notes and comments: Abundant production of spores by *Bruchia bolanderi* allows ample dispersal opportunities, but known localities are few and widely scattered.

Conservation issues: Known localities need to be searched to reconfirm presence of populations. The ephemeral nature of this species, and its occurrence in disturbed sites allow some flexibility in management. Trampling along recreation trails could decimate populations.



Bruchia bolanderi. -- 1. Plants and capsules, with and without calyptra. -- 2. Leaves, one showing cells. From Grout (1936) and Rushing (1986). Figures from Rushing (1986) reprinted with permission of the American Bryological and Lichenological Society.

BUXBAUMIA PIPERI Best
Piper's bug moss, Piper's shield moss
Recent synonyms: None



Status: SAT Appendix 5-H; FEMAT Appendix Table IV-A-3.

Distribution: Endemic to western North America. Southeastern Alaska, Yukon, British Columbia, Washington, Idaho, Montana, Colorado, Oregon, northern California.

Habitat and ecology: Rotten logs, peaty soil and humus, in dense, shady and humid coniferous forest, low elevation to subalpine. The logs and stumps will be in an advanced stage of decay, the kind you can stick your foot into with little exertion.

Description: Protonema persistent, yellow green to dark green, dense and felty, coating the substrate in a nearly solid mat. Leafy plants reduced to a tiny cluster of bracts surrounding the gametangia, to 0.5 mm tall. Seta 5-12 mm long, dark brown, papillose. Capsule ovoid, 4.5-6 x 2.5-3.5 mm, nearly erect, or pointing at about a 45° angle from the seta, sometimes horizontal, somewhat flattened on top and rounded beneath, like a rowboat, the distal end tapering to a point; green when young, yellow-brown to brown when mature, not glossy. Peristome forming a pleated cone at the distal end. When the capsule matures, the papery cuticle separates from the wall of the capsule, and peels backward from the mouth, like a scroll of parchment. Sometimes the cuticle remains smooth, and does not split or peel at all. Grout (1938) described the capsules of *B. piperi* as being at least twice as long as broad.

Distinctive characters: (1) A green, felty protonema, (2) lack of any gloss on the capsule, (3) a cuticle that curls back from the mouth of the capsule, and (4) rotten wood or peaty soil in moist forests.

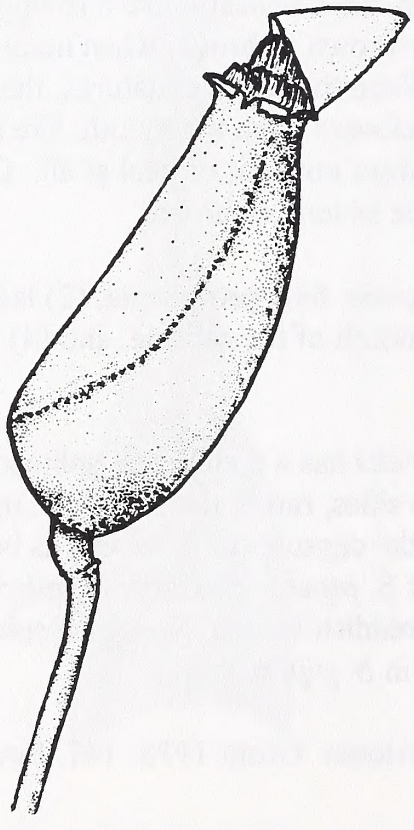
Similar species: *Buxbaumia viridis* has a cuticle that splits longitudinally along the top of the capsule, peeling back toward the sides, rather than from the mouth toward the base, as in *B. piperi*. Grout (1938) described the capsules of *B. viridis* as being about as long as broad, and being much smaller than those of *B. piperi*. *Buxbaumia aphylla*, a rare species on nutrient-poor soil in exposed places, has (1) a reddish-brown, glossy capsule when mature, and (2) a cuticle peeling back from the mouth, as in *B. piperi*.

Other descriptions and illustrations: Grout 1938: 147; Lawton 1971: 29, *Pl. 4*; Schofield 1992: 86, *87*.

Notes and comments: Once seen, *Buxbaumia* is unmistakable and unforgettable. It is probably the most famous moss, known as "bug-on-a-stick." It virtually lacks a leafy plant, and the most conspicuous part is its green, felty protonema. On closer exploration, you may find the distinctive capsules, looking at first glance like hemlock needles sticking out of the side of a

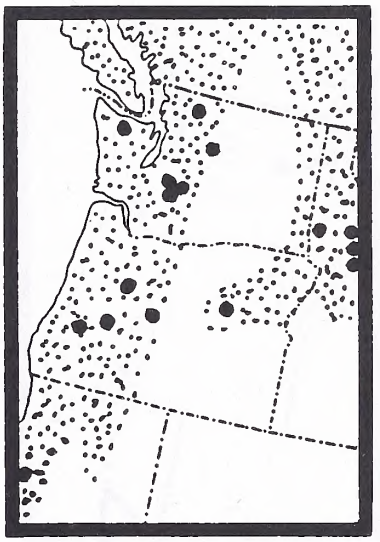
well-rotted log. Where there is one capsule, there are usually more, scattered along the length of the log. The green felts seen on rotten wood and humus are often sterile, and often end up being green filamentous algae. The algal mat of the lichenized basidiomycete fungus *Botrydina botryoides* (also known by its earlier name, *Omphalina ericetorum*), restricted to rotten wood and peaty humus, is very similar to the felt of *Buxbaumia*, but usually sports telltale white mushrooms 2-4 cm tall, with pleated tops, much like a parasol. The only problem in identifying species of *Buxbaumia* is that mature capsules are needed for correct identification. Plants of *B. piperi* with immature green capsules cannot be separated from the look-alike *B. viridis*. In our area, *B. piperi* appears to be widespread, and much more common than *B. viridis*.

Conservation Issues: *Buxbaumia* is dependent on shade and a supply of moist logs in an advanced state of decay. Activities that open up the canopy and deplete inputs of logs in various decay classes could diminish long-term viability of this species. Studies are needed to determine to what extent old-growth forest serves as a source of propagules for recolonizing disturbed sites, such as burns and clearcuts. *Buxbaumia* has been found in stands regenerated in 50-year-old clearcuts, but old-growth forest has always been nearby, presumably supplying needed spores. In a forest landscape intensively managed on 40-year rotations, *Buxbaumia* may disappear if suitable substrate or microclimate is not available for growth, or if sources of propagules no longer exist.



Buxbaumia piperi. -- 1. Capsule, showing cuticle peeling from mouth. From Lawton (1971). Reprinted with permission of the Hattori Botanical Laboratory.

BUXBAUMIA VIRIDIS (D.C.) Moug. & Nestl.
Green bug moss, Green shield moss
Recent synonyms: *Buxbaumia indusiata* Brid.



Status: SAT Appendix 5-H; FEMAT Appendix Table IV-A-3.

Distribution: Interruptedly circumboreal. Europe, China, western North America. In our area, from British Columbia, Alberta, Idaho, Montana, Colorado, Washington and Oregon.

Habitat and ecology: See under *Buxbaumia piperi*.

Description: Essentially the same as *Buxbaumia piperi*, except that on mature capsules, the cuticle splits longitudinally along the top, and peels back toward the sides of the capsule. Grout (1938) described the capsules of *B. viridis* as being about as long as broad.

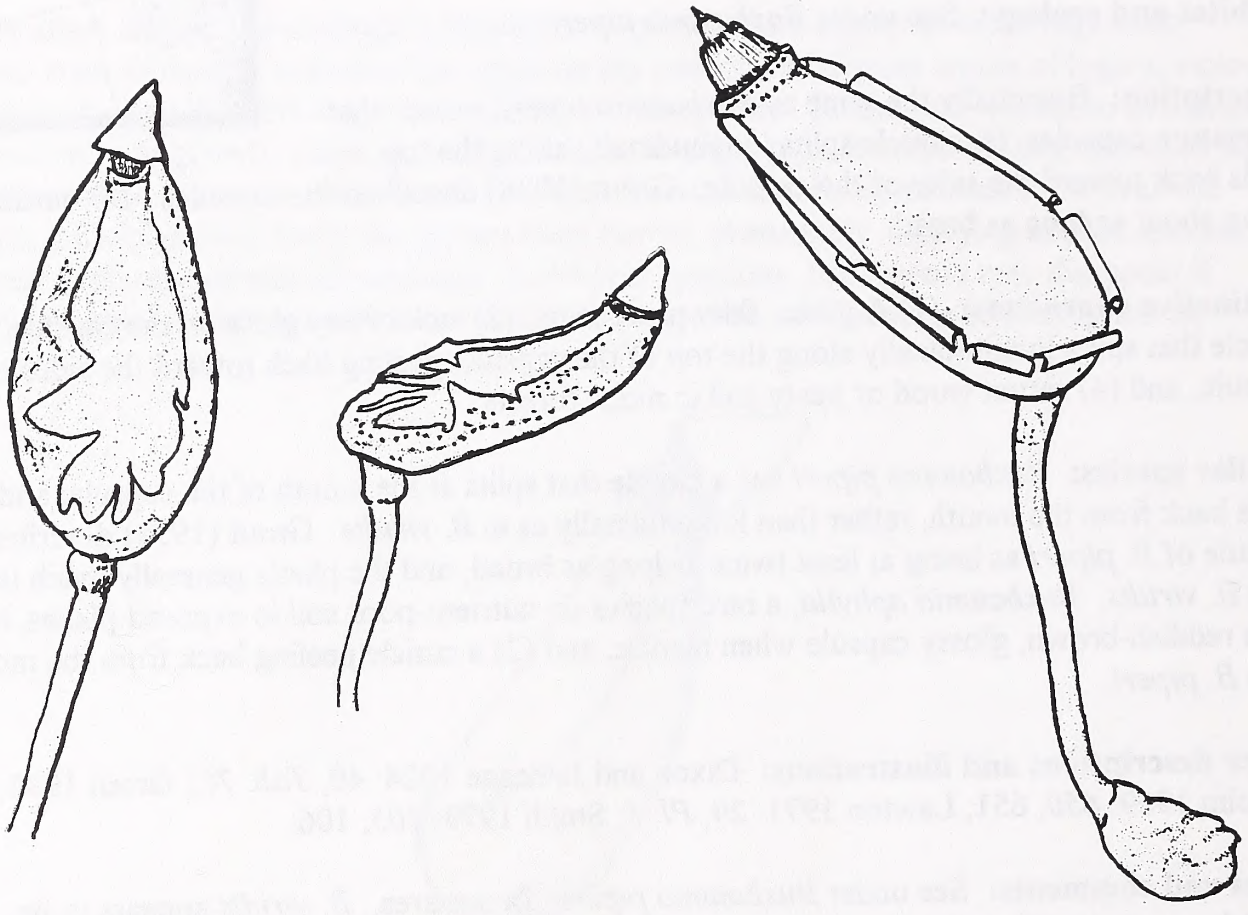
Distinctive characters: (1) A green, felty protonema, (2) lack of any gloss on the capsule, (3) a cuticle that splits longitudinally along the top of the capsule, peeling back toward the sides of the capsule, and (4) rotten wood or peaty soil in moist forests.

Similar species: *Buxbaumia piperi* has a cuticle that splits at the mouth of the capsule, and peels back from the mouth, rather than longitudinally as in *B. viridis*. Grout (1938) described the capsule of *B. piperi* as being at least twice as long as broad, and the plants generally much larger than *B. viridis*. *Buxbaumia aphylla*, a rare species on nutrient-poor soil in exposed places, has (1) a reddish-brown, glossy capsule when mature, and (2) a cuticle peeling back from the mouth as in *B. piperi*.

Other descriptions and illustrations: Dixon and Jameson 1924: 49, *Tab. 7C*; Grout 1938: 147; Nyholm 1969: *650*, 651; Lawton 1971: 29, *Pl. 3*; Smith 1978: *105*, 106;

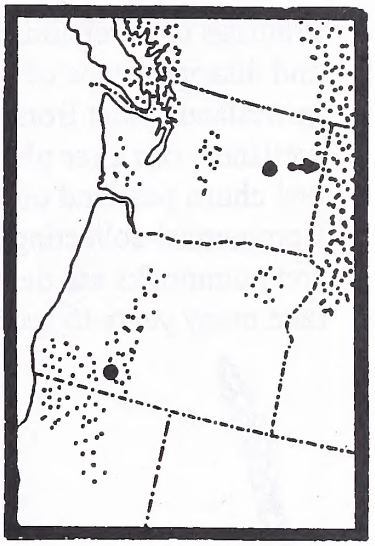
Notes and comments: See under *Buxbaumia piperi*. In our area, *B. viridis* appears to be much less common than *B. piperi*.

Conservation Issues: See under *Buxbaumia piperi*.



Buxbaumia viridis -- 1. Capsules, showing cuticle peeled laterally. From Lawton (1971). Reprinted with permission of the Hattori Botanical Laboratory.

CALLIERGON TRIFARIUM (Web. & Mohr) Kindb.
Blunt water moss, Worm moss
Recent synonym: *Scorpidium trifarium* (Web. & Mohr) Paul



Status: ONHP List 2.

Distribution: Circumboreal, but rare throughout its range. In our area, British Columbia, Alberta, Montana and Oregon.

Habitat and ecology: Forming sods or inconspicuously intermixed with other bryophytes, in calcareous fens, where it grows submerged to emergent in pools, usually in full sunlight. Fen pools may dry up in late summer. *Calliergon trifarium* is one of several species of so-called "brown mosses" that occur in mineral-rich peatlands, or fens. Associated vascular plants in our area include *Eleocharis pauciflora, Carex limosa* and *Scheuchzeria palustris*. Associated bryophyte species in our area include *Hamatocaulis vernicosus, Tomenthypnum nitens, Meesia triquetra* and *Helodium blandowii*.

Description: Plants erect, 4-16 cm tall, brownish-gold or copper-colored to black, unbranched. Shoots round in cross-section, about 1-1.5 mm wide. Leaves concave and imbricate, giving plants a blunt, turgid, worm-like appearance. When wet, the leaves appear to be arranged around the stem in a spiral pattern. Capsules very rare.

Distinctive characters: (1) Sparingly branched, upright, turgid shoots with blunt tips and imbricate concave leaves, (2) fen habitat.

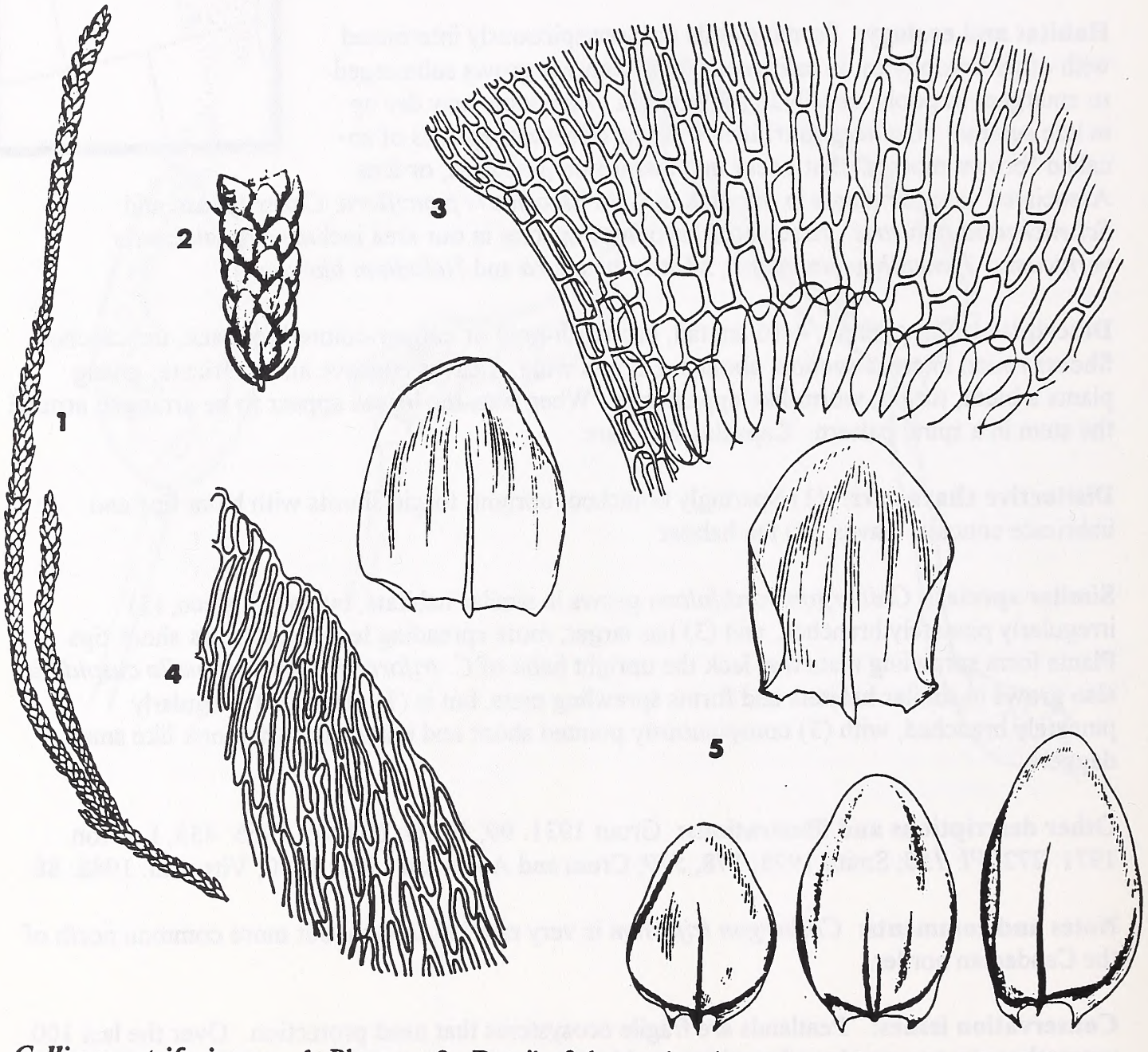
Similar species: *Calliergon cordifolium* grows in similar habitats, but is (1) green, (2) irregularly pinnately branched, and (3) has larger, more spreading leaves and blunt shoot tips. Plants form sprawling mats that lack the upright habit of *C. trifarium*. *Calliergonella cuspidata* also grows in similar habitats and forms sprawling mats, but is (1) green, (2) irregularly pinnately branched, with (3) conspicuously pointed shoot and branch tips that look like small daggers.

Other descriptions and illustrations: Grout 1931: 99, *Pl. 21*; Nyholm 1965: 455; Lawton 1971: 272, *Pl. 150*; Smith 1978: 578, *579*; Crum and Anderson 1981: 1010; Vitt et al. 1988: 88.

Notes and comments: *Calliergon trifarium* is very rare in our area, but more common north of the Candadian border.

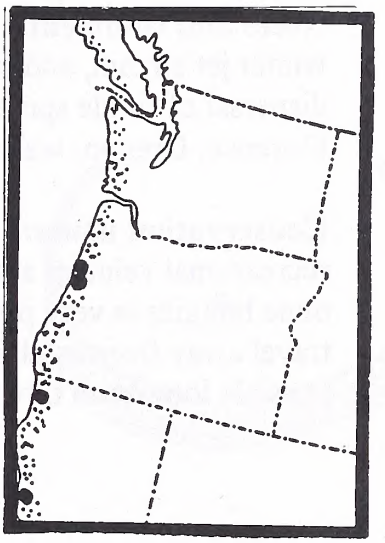
Conservation issues: Peatlands are fragile ecosystems that need protection. Over the last 100 years, those in our area have been impacted by grazing, water diversion and impoundment, drainage projects, road construction, and commercial harvest of peat and sphagnum moss. Most of these threats still exist today. All known localities should be searched to reconfirm presence of populations, and searches for new populations should be conducted. Dewatering from

drainage or diversion, and flooding from impoundment cause replacement of plant communities and disappearance of peatland species. Although federal regulations prohibit building new roads in wetlands, dust from nearby roads can have a significant impact on the nutrient status of wetlands, can alter pH, and can smother small plants such as bryophytes. Livestock may trample and churn peatland until all bryophytes are destroyed, especially around water holes. Commercial collecting of peat can seriously deplete bryophyte diversity in mires. Moss mats and hummocks are destroyed during collection, and tiny pool or hummock-dwelling species may take many years to recover.



Calliergon trifarium. -- 1. Plant. -- 2. Detail of shoot, showing concave leaves. -- 3. Cells at base of leaf. -- 4. Cells at tip of leaf. -- 5. Leaves, showing concavity. From Grout (1931) and Crum and Anderson (1981). Figures from Crum and Anderson (1981) reprinted with permission of Columbia University Press.

CAMPYLOPUS SCHMIDII (C. Muell.) Jaeg.
Golden sand moss
Recent synonym: *Campylopus aureus* Bosch & Sande Lac.



Status: ONHP List 2.

Distribution: Coastal Oregon (Lane County) and northern California (Del. Norte and Mendocino Counties), Mexico, Hawaii, Malaysia, Java, New Guinea, Taiwan, Celebes, Sri Lanka, India, Comoro Islands, Madagascar.

Habitat and ecology: In North America, the species occurs in partially-stabilized coastal sand dunes, within one mile of the ocean. It forms sods in open stands of shore pine, cedar and cypress, where it grows on shaded to exposed sand around the edges of vernal pools. It has also been seen on exposed, seasonally-flooded sand on deflation plains. Plants tolerate flooding in vernal pools, but are also drought-tolerant. Associated species include *Pinus contorta, Carex obnupta, Potentilla pacifica,* and the mosses *Polytrichum piliferum, Racomitrium canescens, Warnstorfia exannulata, Sphagnum mendocinum* and the tiny blackish liverwort *Cephaloziella*.

Description: Plants erect, 2-4 (8) cm tall, golden yellow, olive green to blackish. Leaves narrow, straight and imbricate when dry, widest above the base, 3-5 mm long, with a very wide costa filling ½ to ¾ of blade at base. Basal leaf cells often brown, thin-walled. Most leaves have a well-developed transparent awn at the tips, although awns may be lacking in short, blackish plants. Stems usually covered below by brown or white, minutely papillose rhizoids.

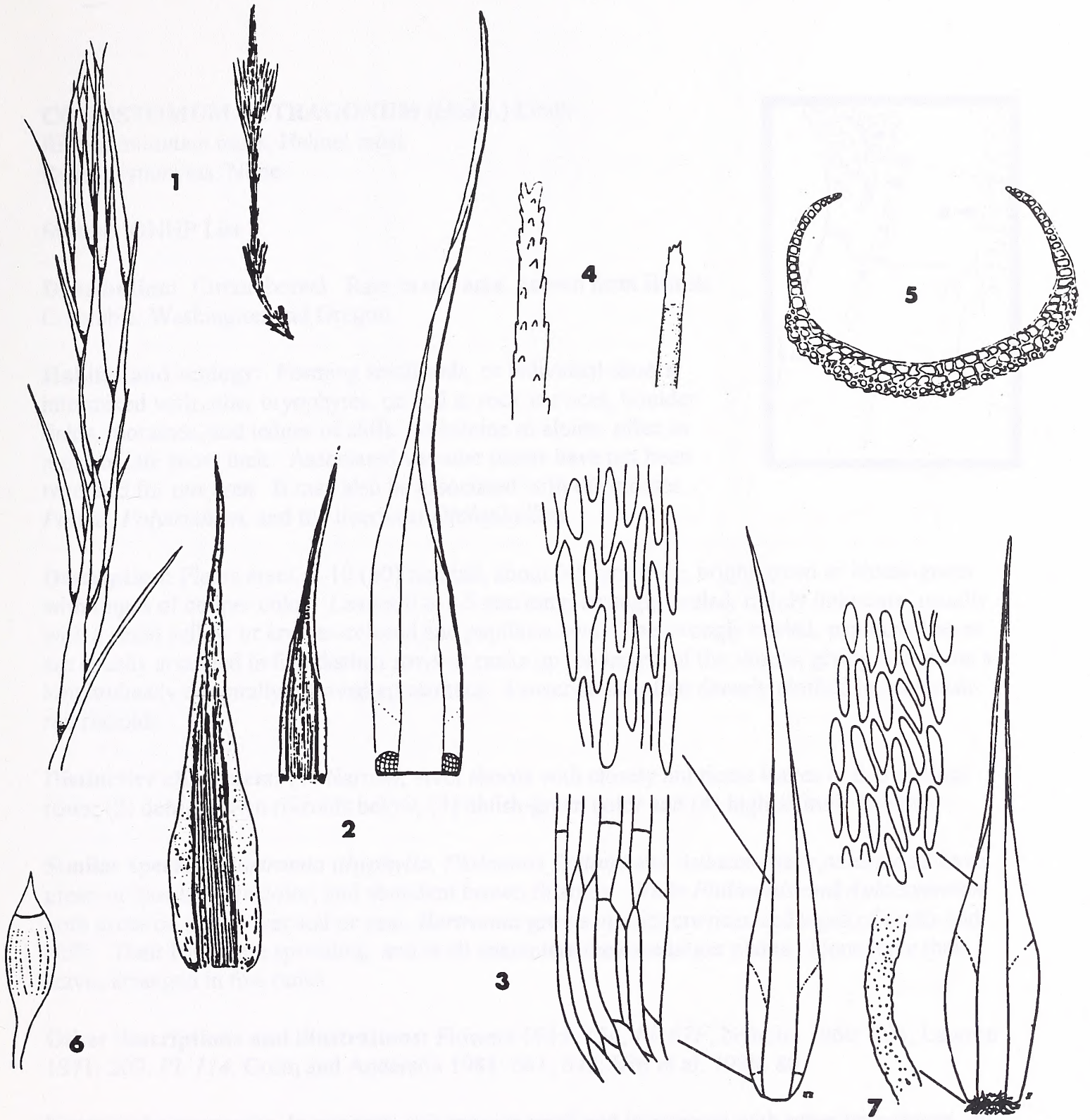
Distinctive characters: A combination of (1) small, erect plants (2) growing on nutrient-poor substrates, with (3) extremely wide costae, will put you in the genus *Campylopus*. *C. schmidii* has (1) stiff, straight leaves with awns, (2) a costa smooth at the back, and (3) papillose rhizoids. Its sandy coastal habitat is also a key feature.

Similar species: *Campylopus atrovirens* looks very similar, but (1) plants are usually dark green to blackish, (2) the basal leaf cells are thick-walled and pitted, and (3) the rhizoids, when present, are smooth. It usually grows on wet peat or wet rocks. *Campylopus introflexus* is a recent immigrant from the Southern Hemisphere, and is spreading rapidly on partially stabilized sand dunes in Oregon and northern California. It differs from *C. schmidii* by its awns that curve at a 90° angle when dry, giving the plants a bristly appearance, with a conspicuous tuft of recurved awns at the tips of the shoots. *Dicranum scoparium* is a larger, yellowish-green moss that occurs on both sand and rotten wood. Its leaves are 5-18 mm long, and are usually falcate and secund. They lack awns and have a narrow costa.

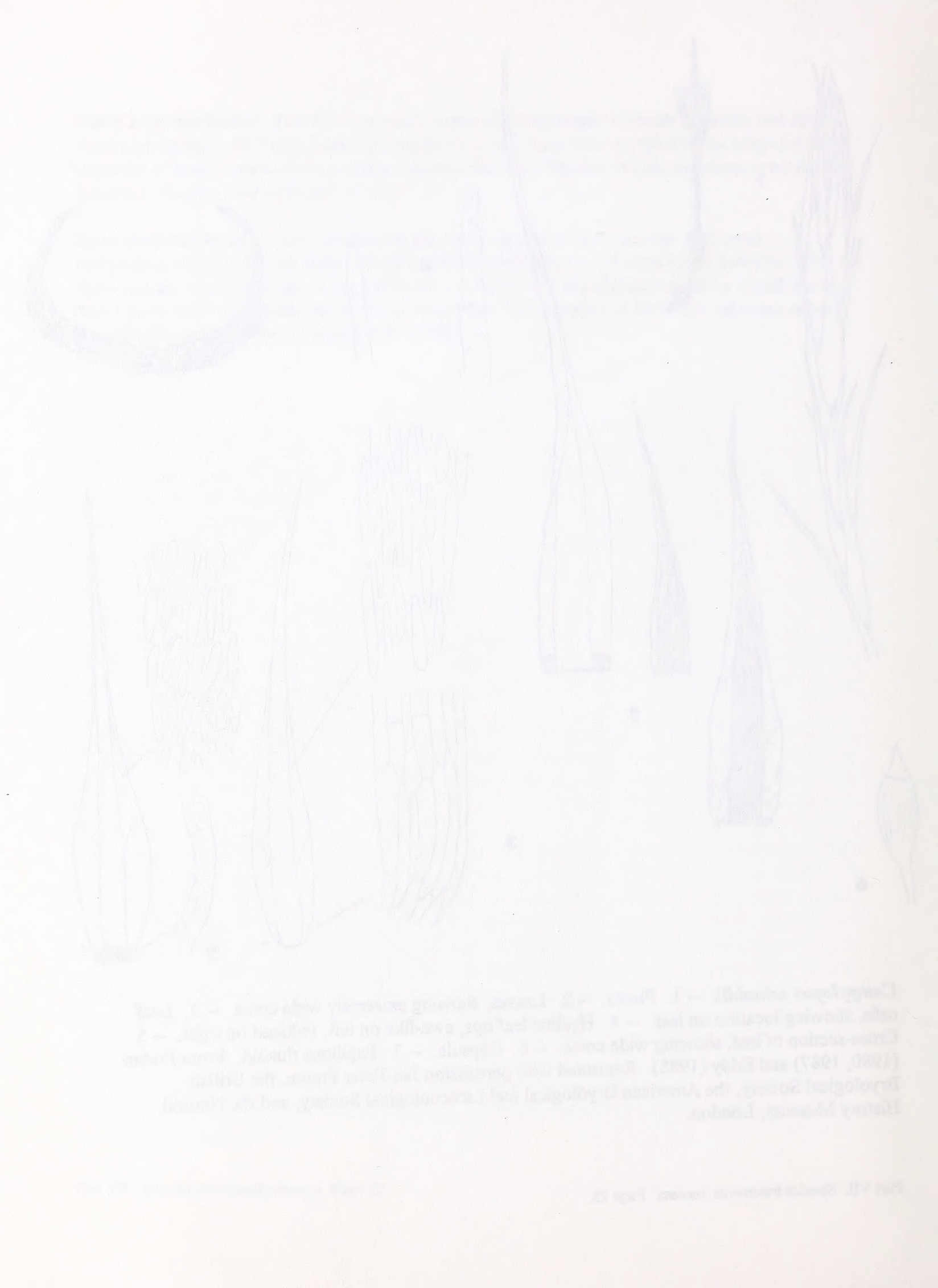
Other descriptions and illustrations: Frahm 1980: *575*, 576; Tan 1983: 358; Frahm 1984: 165, *167*; Frahm 1987: 721, *722*; Frahm and Mohamed 1987: 482, *483*; Eddy 1988: 124, *125*.

Notes and comments: The distributional pattern of *Campylopus schmidii* parallels that of the winter jet stream, and North American populations may have been established by long-distance dispersal of single spores from southeast Asia or Hawaii. The first North American record, from Florence, Oregon, was collected in 1933.

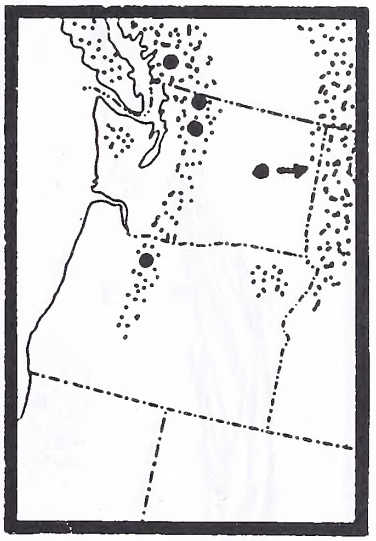
Conservation issues: New populations should be sought in likely habitat. Off-road recreational vehicles are the major threat to known populations of *Campylopus schmidii*. Use of dune buggies is very popular in the habitat of this moss, and populations could be wiped out by travel away from established trails. Plant succession and lowering of the water table are other possible long-term threats to population viability.



Campylopus schmidii. -- 1. Plants. -- 2. Leaves, showing extremely wide costa. -- 3. Leaf cells, showing location on leaf. -- 4. Hyaline leaf tips, awn-like on left, reduced on right. -- 5. Cross-section of leaf, showing wide costa. -- 6. Capsule. -- 7. Papillose rhizoid. From Frahm (1980, 1987) and Eddy (1988). Reprinted with permission Jan-Peter Frahm, the British Bryological Society, the American Bryological and Lichenological Society, and the Natural History Museum, London.



CONOSTOMUM TETRAGONUM (Hedw.) Lindb.
Ribbed mountain moss, Helmet moss
Recent synonyms: None



Status: ONHP List 3.

Distribution: Circumboreal. Rare in our area, known from British Columbia, Washington and Oregon.

Habitat and ecology: Forming small sods, or individual shoots intermixed with other bryophytes, on soil in rock crevices, boulder fields, moraines, and ledges of cliffs. Subalpine to alpine, often in areas of late snow melt. Associated vascular plants have not been recorded for our area. It may also be associated with the mosses *Pohlia*, *Polytrichum*, and the liverwort *Diplophyllum*.

Description: Plants erect, 2-10 (50) mm tall, about 0.5 mm wide, bright green or bluish-green with tinges of copper color. Leaves 0.8-1.5 mm long, strongly keeled, tightly imbricate, usually with a small yellow or copper-colored and papillose awn. The strongly keeled, papillose leaves are usually arranged in five distinct rows or ranks up the length of the shoots, giving the plants a longitudinally or spirally grooved appearance. Lower stems often densely clothed in brownish-red rhizoids.

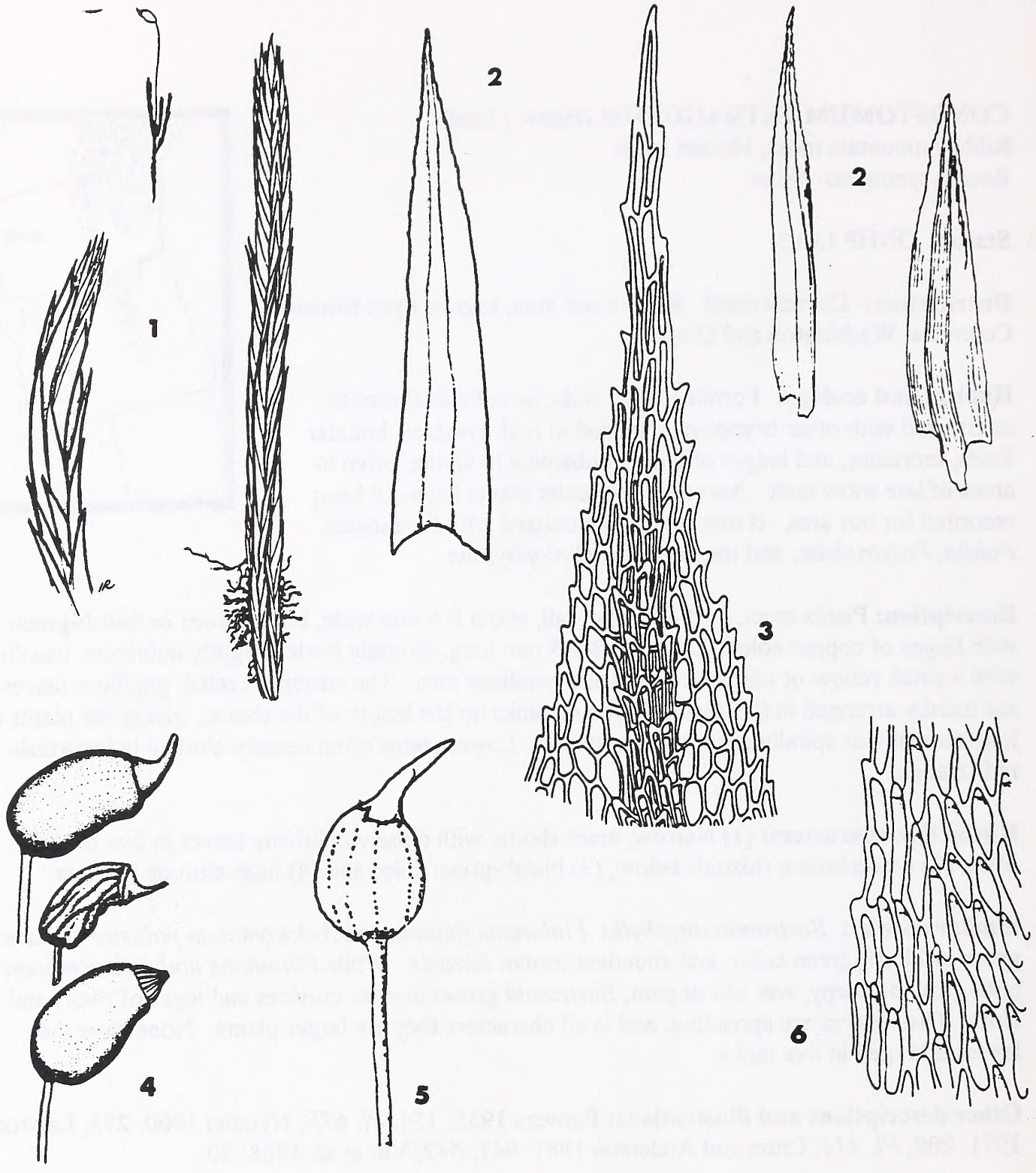
Distinctive characters: (1) Narrow, erect shoots with closely imbricate leaves in five distinct rows, (2) dense brown rhizoids below, (3) bluish-green color and (4) high-altitude habitats.

Similar species: *Bartramia ithyphylla, Philonotis fontana* and *Aulacomnium palustre* all have green or bluish-green color, and abundant brown rhizoids. While *Philonotis and Aulacomnium* both grow on seepy, wet soil or peat, *Bartramia* grows in drier crevices and leges of rocks and cliffs. Their leaves are spreading, and in all characters they are larger plants. None have their leaves arranged in five ranks.

Other descriptions and illustrations: Flowers 1935: 154, *Pl. 67F*; Nyholm 1960: 293; Lawton 1971: 209, *Pl. 114*; Crum and Anderson 1981: 641, *642*; Vitt et al. 1988: 80.

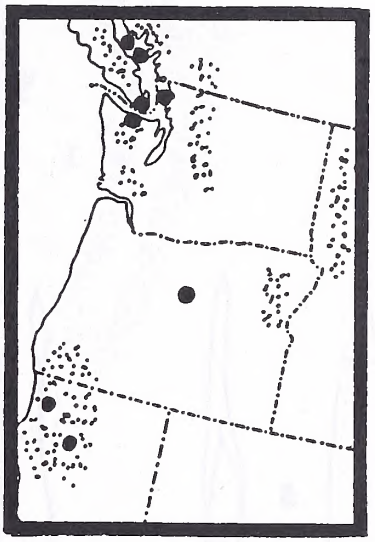
Notes and comments: In our area, this moss is small and intermixed with other bryophytes, on exposed rocks at and above treeline. Sites will generally be remote and visited by few people.

Conservation issues: Look for new populations, and assess potential threats from recreational activity. Rock climbing and hiking can have local impacts, but not over large areas of subalpine and alpine. Air pollution could be a serious long-term threat, as species growing on ridgetops are subject to accumulation of aerosols from cloud interception. Long-term air quality monitoring would identify possible threats and impacts.



Conostomum tetragonum. -- 1. Plants and capsule, shoot on right showing ranked leaves on right; plant in upper left about natural size. -- 2. Leaves. -- 3. Cells at tip of leaf. -- 4. Mature capsules, wet and dry, with and without an operculum. -- 5. Immature capsule, with calyptra. -- 6. Leaf cells in middle of leaf, showing papillae formed at upper ends of cells. From Flowers (1935), Lawton (1971) and Crum and Anderson (1981). Figures from all but Flowers (1935) reprinted with permission of the Hattori Botanical Laboratory, and Columbia University Press.

CRUMIA LATIFOLIA (Kindb. *in* Mac.) Schof.
Three-lined limestone moss
Recent synonym: *Scopelophila latifolia* (Kindb. *in* Mac.) Ren. & Card.



Status: ONHP List 2.

Distribution: Western North America, Russia. In our area it occurs in both coastal and arid interior British Columbia, Washington, Oregon, California, Nevada.

Habitat and ecology: Forming dense sods or cushions on wet rocks and cliff faces, usually calcareous. Sometimes submerged in flowing streams, or on cement. *Crumia latifolia* is one of a suite of calcium-tolerant mosses that in our area includes *Gymnostomum* species and *Fissidens grandifrons*. Many other species, common on other rock types, may also occur on calcareous rocks.

Description: Plants erect, 1-5 cm tall. Leaves tongue-shaped, dark green to brownish-red or black, 3-5 mm long, crisped or contorted when dry, but usually plane if encrusted with limey deposits. A band of thickened cells at the margin of the leaf are darker than the blade, and are often somewhat recurved on dry leaves. Together with the prominent costa, they are usually visible at the back of the leaf as three raised, shiny brown or orange lines. Lower stems often have reddish-brown rhizoids. Capsules are rare, with the peristome teeth straight.

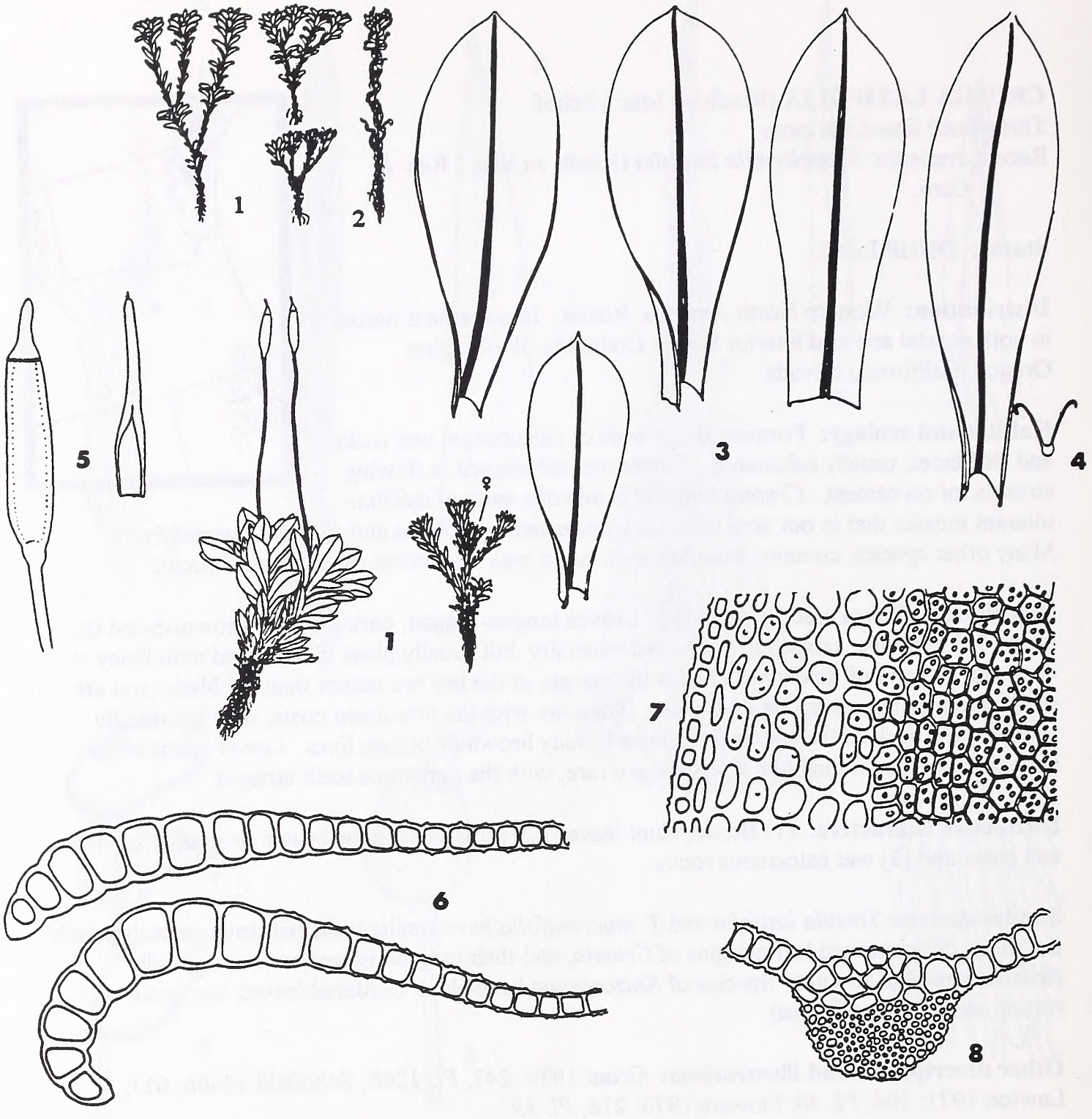
Distinctive characters: (1) Broad, blunt leaves, (2) prominent, shiny brown or orange borders and costa and (3) wet calcareous rocks.

Similar species: *Tortula latifolia* and *T. mucronifolia* have similarly shaped leaves, but they lack the shiny, differentiated leaf margins of *Crumia*, and their long peristome teeth are spirally twisted instead of straight. Species of *Rhizomnium* have blunt, bordered leaves, but occur on rotting wood or on wet peat.

Other descriptions and illustrations: Grout 1939: 247, *Pl. 120B*; Schofield 1966b: 611; Lawton 1971: 104, *Pl. 46*; Flowers 1973: 216, *Pl. 39*.

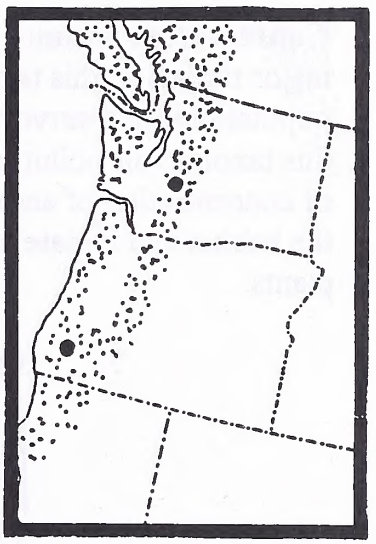
Notes and comments: Rare, but may be abundant locally. Calcareous rocks are rare in our area, and support a distinctive bryophyte flora not found on other substrates. The best remaining examples of limestone habitat may be on federal lands.

Conservation issues: Limestone is quarried for lime in several places in the region, and some of the largest exposures of this kind of rock have been destroyed. The bryoflora of calcareous outcroppings needs special inventory to identify its composition, and representative examples need protection.



Crumia latifolia. -- 1. Plants, wet, one with capsules. -- 2. Plant, dry. -- 3. Leaves. -- 4. Cross-section of leaf, showing prominent costa and recurved margins. -- 5. Capsule and calyptra. -- 6. Cross-section of thickened cells at margin of leaves. -- 7. Cells along margin of leaf, showing band of thick-walled cells; note papillae on inner leaf cells, and lack of papillae on marginal cells. -- 8. Cross-section of leaf blade and costa, showing papillae and thickened costal cells. From Schofield (1966b) and Flowers (1973). Reprinted with permission of the National Research Council of Canada, and Brigham Young University Press.

ENCALYPTA BREVICOLLA var. CRUMIANA (Horton) Crum & Anderson
Crum's extinguisher moss
Recent synonym: *Encalypta brevicolla* ssp. *crumiana* Horton



Status: FEMAT Appendix Table IV-A-3; ROD Table C-3; ONHP List 1.

Distribution: Endemic to the Pacific Northwest. Known only from coastal Curry County, Oregon, and Mount Rainier National Park, Washington.

Habitat and ecology: At its two known localities, this taxon grows on soil in shaded crevices in igneous rocks, along ridgetops subject to frequent fog penetration. Associated vascular species at the Oregon site include *Cheilanthes gracillima, Selaginella wallacei* and *Sedum*. Associated bryophytes may include the mosses *Dryptodon patens, Claopodium bolanderi, Racomitrium heterostichum, Racomitrium lanuginosum, Racomitrium canescens, Polytrichum piliferum, Amphidium*, the liverwort *Gymnomitrion*, crustose lichens and *Cladonia*.

Description: Plants erect, to 25 mm tall, leaves light green at shoot tips, dark green to blackish below, contorted when dry, keeled, with a prominent, shiny green or brown costa that is plainly spiny-papillose at back toward tip of leaf. Leaf blades relatively broad, oblong or obovate, hooded when dry, the cells with walls straight and with simple papillae. Most leaves with awns to 2 mm. Seta 2.5-17 mm long. Capsules smooth or wrinkled, but not ribbed, 1.1-3.5 mm long, narrowly cylindric. Peristome teeth $\leq$ 0.4 mm long, smooth, white to peach-colored.

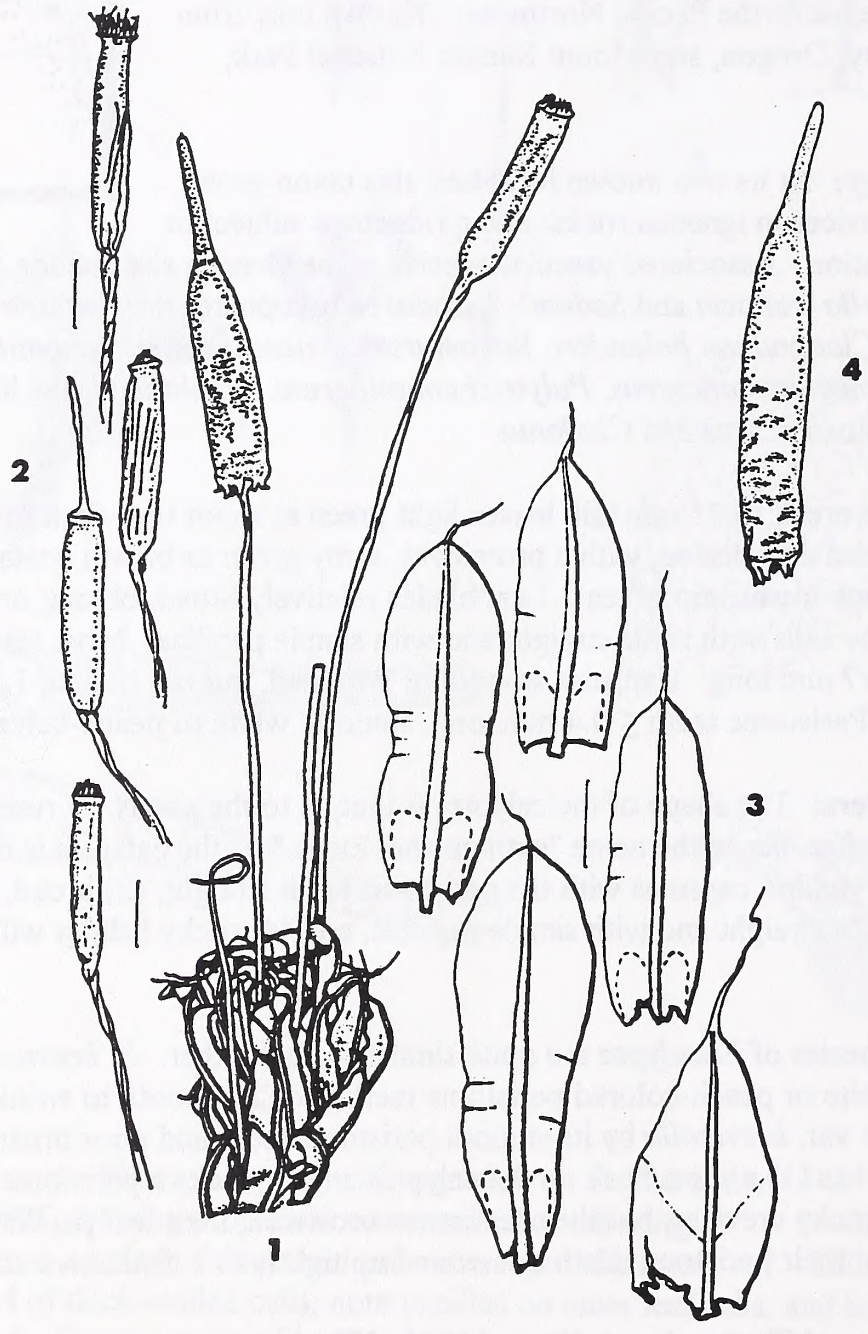
Distinctive characters: The shape of the calyptra is unique to the genus. It resembles an old-fashioned candle-snuffer, hence the name "extinguisher moss." If the calyptra is missing, the combination of (1) cylindric capsules with the peristome teeth straight, (2) broad, awned leaves, (3) the cells with walls straight and with simple papillae, and (4) rocky habitat will place you in the correct genus.

Similar species: Species of *Encalypta* are quite similar to each other. *E. brevicolla* var. *crumiana* has (1) white or peach-colored peristome teeth and (2) smooth to wrinkled capsules. It is distinguished from var. *brevicolla* by its smooth peristome teeth and poor ornamentation of the spores. *E. brevipes* has (1) a short beak on the calyptra and (2) lacks a peristome. Some species of *Tortula* occur in rocky crevices, but their leaves are brownish, their leaf papillae are C-shaped or antler-shaped, and their peristome teeth are wound up tightly in a distinctive cone.

Other descriptions and illustrations: Horton 1983: 472.

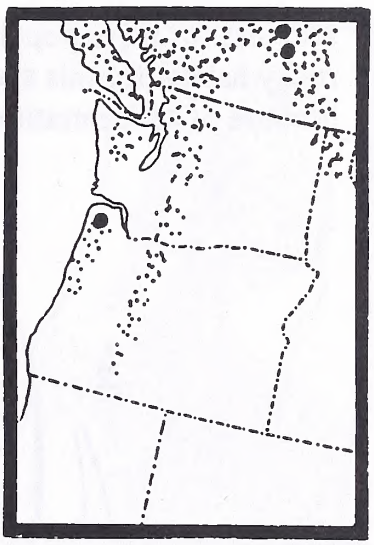
Notes and comments: The only known sites for *Encalypta brevicolla* var. *crumiana* are all on federal lands.

Conservation issues: Road construction, quarrying, air pollution and overcollecting are the major threats to this taxon. Known sites should be searched to reconfirm presence of populations, and surveys for new populations need to be conducted. Although the sensitivity of this taxon to air pollution is unknown, bryophytes on fog-drenched ridges are vulnerable because of concentration of aerosols at these locations. Where shaded by forest, logging could dry out the habitat and initiate invasion by more drought-tolerant species of bryophytes or vascular plants.



***Encalypta brevicolla* ssp. *crumiana*.** -- 1. Plant with capsules, one capsule with calyptra. -- 2. Capsules, with and without operculum. -- 3. Leaves. -- 4. Calyptra. From Horton (1983). Reprinted with permission of the Hattori Botanical Laboratory.

ENCALYPTA BREVIPES Schljak.
Stubby extinguisher moss
Recent synonyms: None



Status: ONHP List 2.

Distribution: Interruptedly circumboreal, but rare throughout its range and apparently restricted to unglaciated regions. In North America, known from unglaciated mountains in Alaska, Yukon, Alberta, and Saddle Mountain, Oregon.

Habitat and ecology: Soil on ledges and in crevices on cliffs, usually on igneous or siliceous rocks. Sites are subject to frequent fog penetration. Associated vascular species may include *Cheilanthes gracillima, Selaginella wallacei* and *Sedum*. Associated bryophytes may include the mosses *Dryptodon patens, Claopodium bolanderi, Racomitrium heterostichum, Racomitrium lanuginosum, Racomitrium canescens, Polytrichum piliferum, Amphidium*, the liverwort *Gymnomitrion,* crustose lichens and *Cladonia*.

Description: Plants erect, to 13 mm tall, leaves light green at tip of shoots, dark green to blackish below, contorted and incurved when dry, keeled, with a prominent, shiny green or brown costa with few or no obvious papillae at the back toward the leaf tip. Leaf blades broad, oblong or obovate, the cells with straight walls and simple papillae. Most leaves with awns to 2.5 mm. Seta 1-3 mm long. Capsules smooth, 1.1-3.0 mm long, narrowly cylindric. Peristome absent.

Distinctive characters: The shape of the calyptra is unique to the genus. It resembles an old-fashioned candle-snuffer, hence the name "extinguisher moss." If the calyptra is missing, the combination of (1) cylindric capsules with the peristome teeth straight, (2) broad, awned leaves, (3) the cells with walls straight and with simple papillae, and (4) rocky habitat will place you in the correct genus.

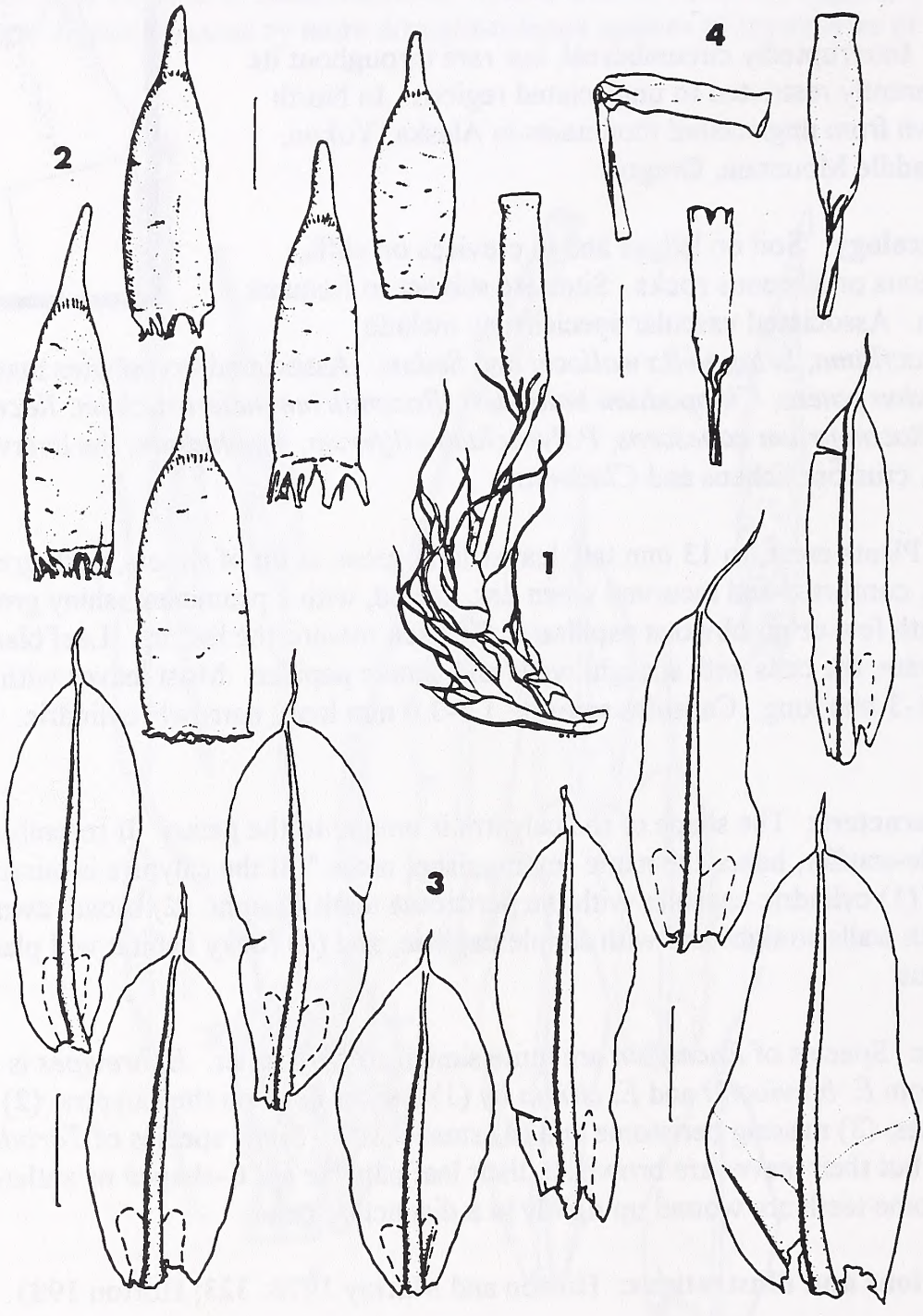
Similar species: Species of *Encalypta* are quite similar to each other. *E. brevipes* is distinguished from *E. brevicolla* and *E. ciliata* by (1) a short beak on the calyptra, (2) smooth to wrinkled capsules, (3) missing peristome and (4) smaller size. Some species of *Tortula* occur in rocky crevices, but their leaves are brownish, their leaf papillae are C-shaped or antler-shaped, and their peristome teeth are wound up tightly in a distinctive cone.

Other descriptions and illustrations: Horton and Murray 1976: 323; Horton 1983: 484.

Notes and comments: *Encalypta brevipes* is very rare in our area.

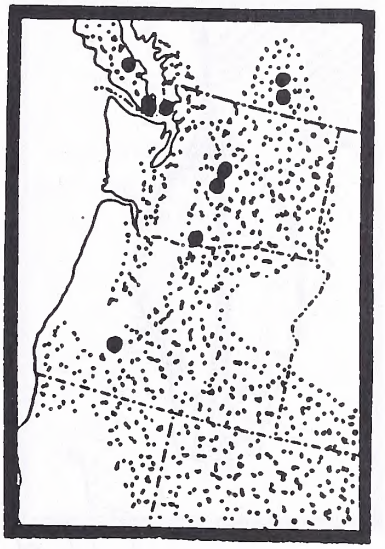
Conservation issues: Road construction, quarrying, air pollution and overcollecting are the major threats to this species. The habitat at Saddle Mountain needs to be documented to aid in

searches for more populations at other localities. Quarrying and road construction could destroy rocky habitat for this species. Sites on fog-drenched ridges could be at risk from air pollution, because of concentration of aerosols at these locations.



Encalypta brevipes. -- 1. Plant with capsule. -- 2. Calyptrae. -- 3. Leaves. -- 4. Capsules. From Horton (1983). Reprinted with permission of the Hattori Botanical Laboratory.

FUNARIA MUHLENBERGII Turn.
Western pinwheel moss, Muhlenberg's cord moss
Recent synonym: *Funaria americana* Lindb.



Status: ONHP List 2.

Distribution: Western North America and western Europe. In the Pacific Northwest, known from Washington, Oregon and California.

Habitat and ecology: Forming small tufts on dry exposed soil, often among rocks or on cliff ledges, in open areas free of competition from other vegetation. It may be restricted to lower elevations. Frequently cited as being a calciphile, it has been found in Oregon on serpentine soils, but is also reported to occur on soils derived from igneous rocks. Look for it in seasonally wet "rock garden" habitats, with *Plectritis congesta, Mimulus guttatus, Escscholzia californica, Clarkia, Riccia sorocarpa, Didymodon* and *Bryum*. The leaves of *Funaria muhlenbergii* turn whitish by early summer, and plants practically disappear in the heat.

Description: Plants erect, to 5 mm tall. Leaves to 3 mm long, clustered at the base of the seta, somewhat contorted when dry, translucent because of large cells visible under dissecting scope. The costa ends before the apex of the leaf. Seta brown, straight, to 18 mm long. Capsules reddish brown, lacking an annulus, the neck longitudinally furrowed but the urn smooth.

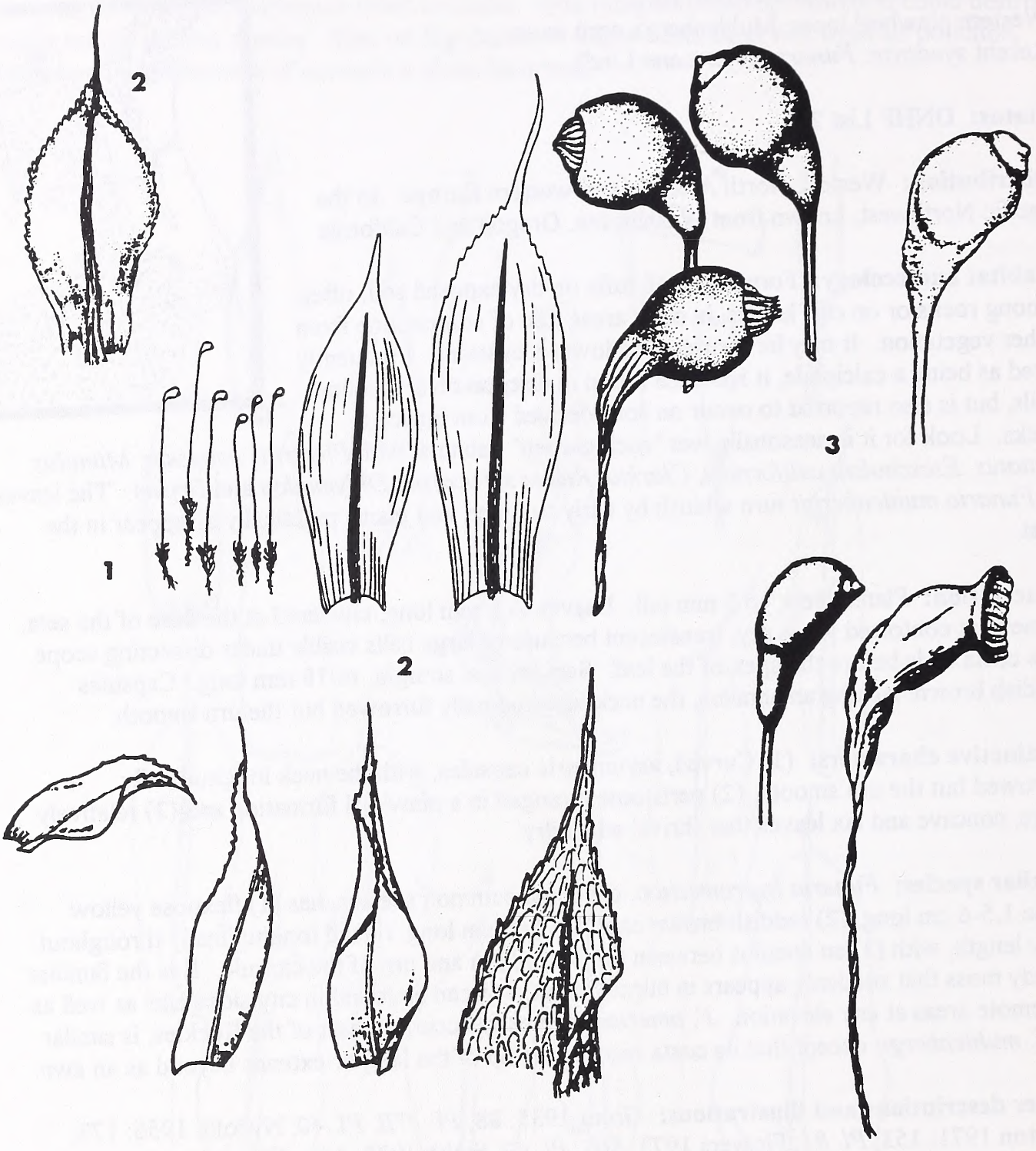
Distinctive characters: (1) Curved, asymmetric capsules, with the neck longitudinally furrowed but the urn smooth, (2) peristome arranged in a pinwheel formation and (3) relatively large, concave and lax leaves that shrivel when dry.

Similar species: *Funaria hygrometrica*, our most common species, has (1) flexuose yellow setae 1.5-6 cm long, (2) reddish-brown capsules 2-3 mm long, ribbed longitudinally throughout their length, with (3) an annulus between the operculum and urn of the capsule. It is the familiar weedy moss that suddenly appears in burned areas, and can be found in city sidewalks as well as in remote areas at any elevation. *F. americana,* mostly occurring east of the Rockies, is similar to *F. muhlenbergii* except that its costa reaches the tip of the leaf, or extends beyond as an awn.

Other descriptions and illustrations: Grout 1935: 88, *Pl. 27B, Pl. 40*; Nyholm 1956: 173; Lawton 1971: 153, *Pl. 81*; Flowers 1973: 303, *Pl. 62*; Smith 1978: 340, *341*.

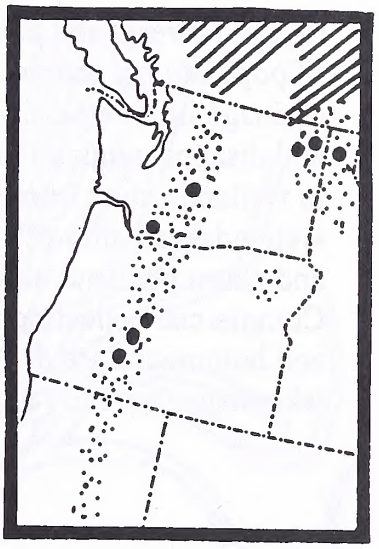
Notes and comments: Smith (1980) clarified the taxonomy and disparate distributions of this species and *Funaria americana* of eastern North America.

Conservation issues: Road construction and quarrying are the major threats to this species, and could destroy rocky habitat. Inventories are needed to locate additional populations. It should be sought in spring, before the rocky habitats become too desiccated.



Funaria muhlenbergii. -- 1. Plants with capsules, about natural size. -- 2. Leaves, one showing cells. -- 3. Capsules, immature and mature, with and without operculum. From Grout (1935), Flowers (1973) and Smith (1978). Figures from all but Grout (1935) reprinted with permission of Brigham Young University Press, and Cambridge University Press.

HELODIUM BLANDOWII (Web. & Mohr) Warnst.
Blandow's feather moss, wetland plume moss
Recent synonyms: None



Status: ONHP List 2.

Distribution: Circumboreal, extending south in the Cascades almost to California, and south in the Rocky Mountains to Arizona.

Habitat and ecology: Forming mats and small hummocks in montane fens, usually with calcareous groundwater. Sometimes under sedges and shrubs around the edges of mires, or along streamlets in mires. Associated vascular species include *Betula glandulosa, Salix geyeriana, Carex limosa, Eleocharis pauciflora* and *Scheuchzeria palustris*. Associated mosses include *Aulacomnium palustre, Calliergon stramineum, Hamatocaulis vernicosus, Meesia triquetra,* and *Tomenthypnum nitens*.

Description: Plants ascending, but actually pleurocarpous, yellow-green, closely pinnately branched, the branches all in one plane like a feather. Stems densely clothed in green filamentous paraphyllia, becoming brown below, mostly without papillae. Stem leaves large, appressed except at the tips, decurrent, with paraphyllia emanating from the decurrent leaf bases. Branch leaves small and contorted when dry, the oblong cells papillose near the upper ends. Capsules rare.

Distinctive characters: (1) Flattened, feather-like branching pattern, (2) yellow-green color, (3) dense paraphyllia on stems and (4) peatland habitat.

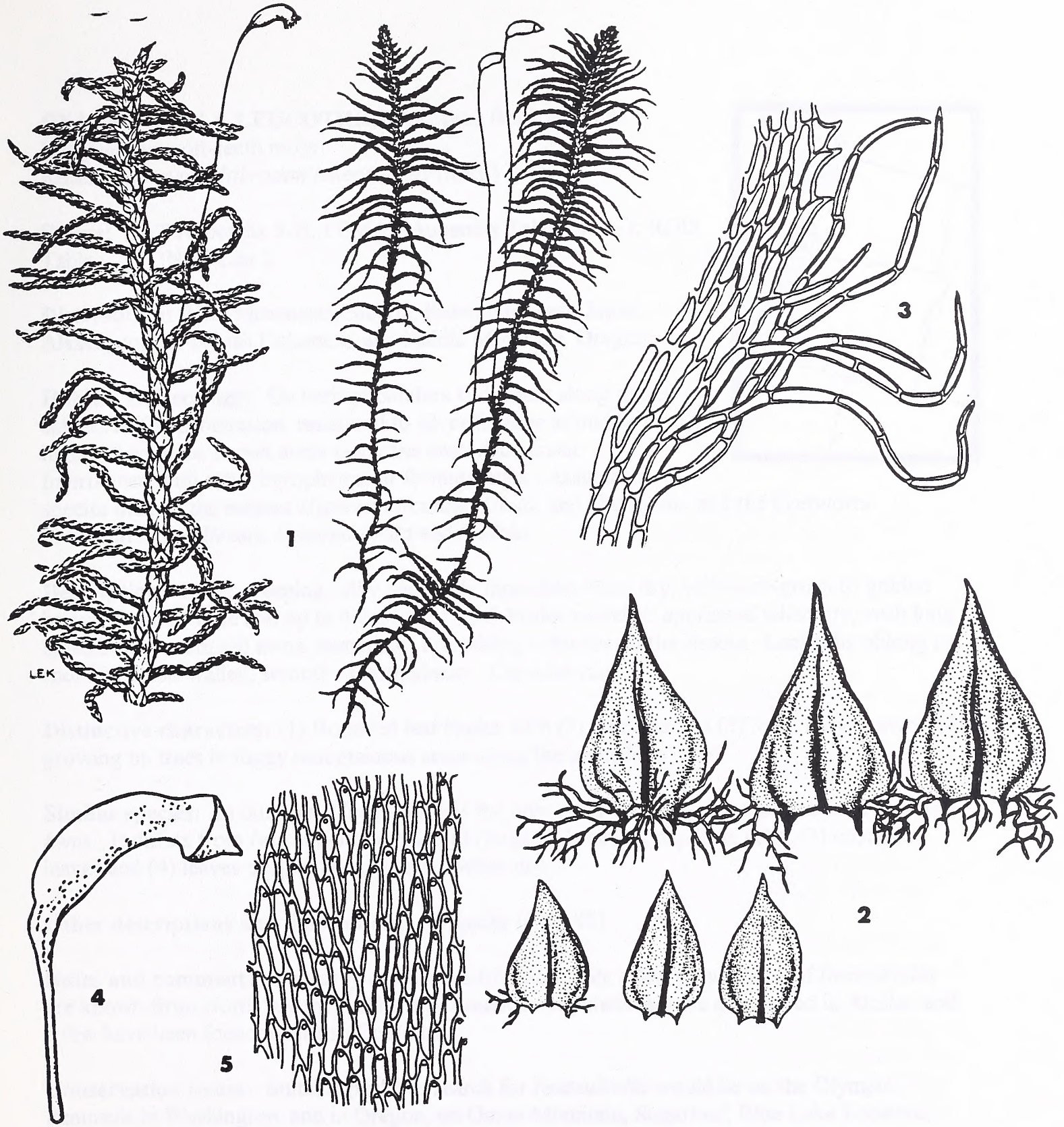
Similar species: *Eurhynchium oreganum* has a pinnate branching habit, but (1) it lacks paraphyllia and, (2) as a low to middle-elevation forest species, never occurs in montane fens. *Eurhynchium praelongum*, occurring in swamps and shrub-swamps, also lacks paraphyllia. *Abietinella abietina* looks very similar to *Helodium*, but grows in dry, wooded or rocky, calcareous sites, and does not occur in our area. Its paraphyllia are papillose, and the leaf cells are more rounded and papillose in the middle.

Other descriptions and illustrations: Grout 1934: 179; Nyholm 1960: 390; Lawton 1971: 261, *Pl. 145*; Flowers 1973: 399, *Pl. 90*; Crum and Anderson 1981: 912, *913*; Vitt et al. 1988: 85.

Notes and comments: *Helodium blandowii* should be sought wherever other distinctive fen mosses such as *Hamatocaulis vernicosus, Meesia triquetra,* and *Tomenthypnum nitens* occur. These are tell-tale components of so-called "brown moss fens."

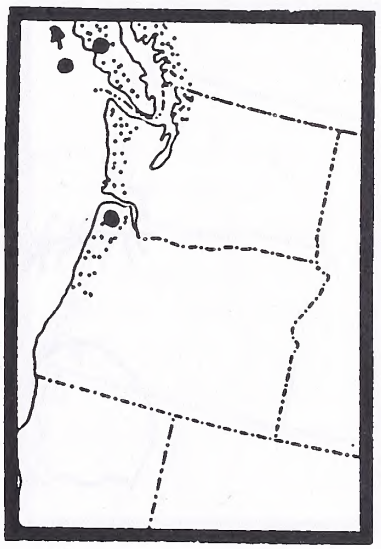
Conservation issues: Peatlands are fragile ecosystems that need protection. Over the last 100 years, those in our area have been impacted by grazing, water diversion and impoundment, drainage projects, road construction, and commercial harvest of peat and sphagnum moss. Most

of these threats still exist today. All known localities should be searched to reconfirm presence of populations, and new populations should be sought in likely habitat. Dewatering from drainage or diversion, and flooding from impoundment cause replacement of plant communities and disappearance of peatland species. Although federal regulations prohibit building new roads in wetlands, dust from nearby roads can have a significant impact on the nutrient status of wetlands, can alter pH, and can smother small plants such as bryophytes. Livestock may trample and churn peatland until all bryophytes are destroyed, especially around water holes. Commercial collecting of peat can seriously deplete bryophyte diversity in mires. Moss mats and hummocks are destroyed during collection, and tiny pool or hummock-dwelling species may take many years to recover.



Helodium blandowii. -- 1. Plants with capsules. -- 2. Leaves with paraphyllia emanating from alar region. -- 3. Detail of paraphyllia at base of leaf. -- 4. Capsule. -- 5. Cells in middle of leaf, showing papillae at upper end of cells. From Lawton (1971), Flowers (1973) and Crum and Anderson (1981). Reprinted with permission of the Hattori Botanical Laboratory, Brigham Young University Press, and Columbia University Press.

IWATSUKIELLA LEUCOTRICHA (Mitt.) Buck & Crum
Hairy leaf-tip soft-teeth moss
Recent synonym: *Habrodon leucotrichus* (Mitt.) Perss.



Status: SAT Appendix 5-H; FEMAT Appendix Table IV-A-3; ROD Table C-3; ONHP List 2.

Distribution: Ural Mountains, Siberia, Russian far east, Japan, Alaska, coastal British Columbia, and Saddle Mountain, Oregon.

Habitat and ecology: On bark of conifers and alders along ridges subject to fog penetration, restricted to silver fir zone at middle to higher elevations, in wet areas along the immediate coast. Intertwined with other bryophytes, or forming mats. Associated species include the mosses *Hypnum circinale, Ulota,* and *Dicranum,* and the liverworts *Frullania nisquallensis, Douinia ovata* and *Radula.*

Description: Plants creeping, silky and finely threadlike when dry, yellowish-green to golden brown, 0.5 mm wide and up to 3 cm long. Leaf blades rounded, appressed when dry, with long spreading or recurved awns, sometimes resembling cobwebs on the shoots. Leaf cells oblong or rhombic, thick-walled, smooth. Costa absent. Capsules rare.

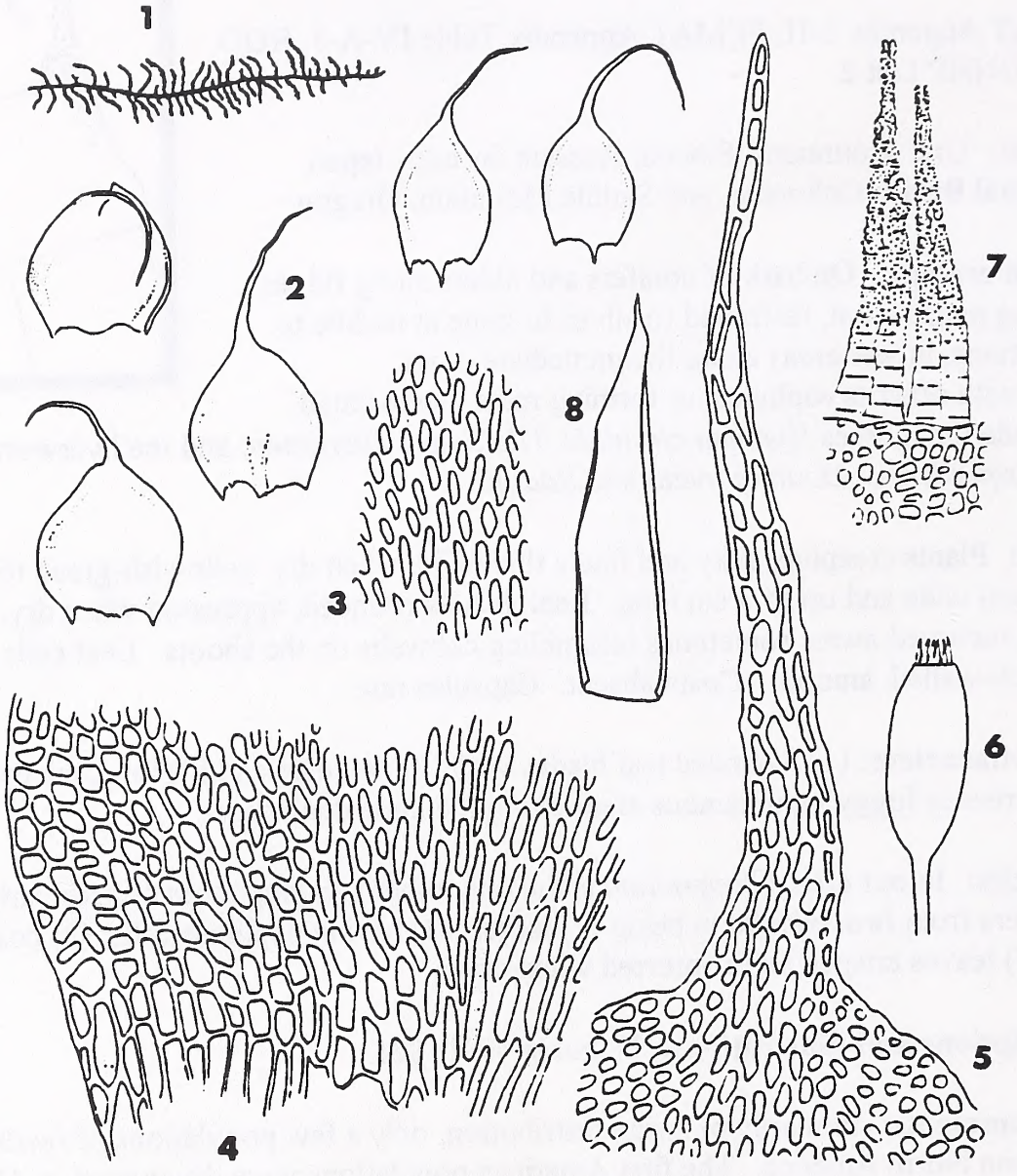
Distinctive characters: (1) Rounded leaf blades with (2) no costa and (3) long, curved awns, (4) growing on trees in foggy mountainous areas along the immediate coast.

Similar species: In our area, *Claopodium* is the only other creeping moss on tree bark that has awns. It differs from *Iwatsukiella* in being (1) larger, (2) having papillose cells, (3) costate leaves and (4) leaves crisped and contorted when dry.

Other descriptions and illustrations: Noguchi 1991: 821.

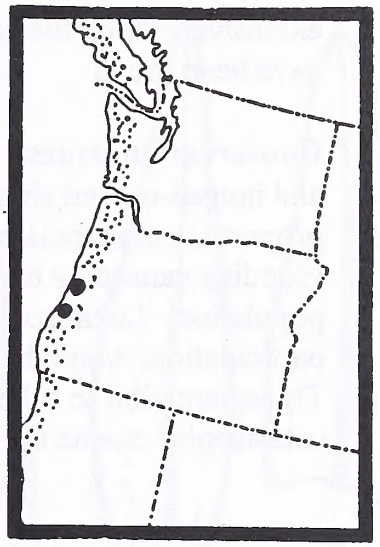
Notes and comments: Primarily of Asian distribution, only a few populations of *Iwatsukiella* are known from North America. The first American populations were discovered in Alaska, and a few have been found in British Columbia.

Conservation issues: Suitable peaks to search for *Iwatsukiella* would be on the Olympic Peninsula in Washington, and in Oregon, on Onion Mountain, Sugarloaf, Blue Lake Lookout, Mt. Hebo and Marys Peak, the last two on the Siuslaw National Forest. Roading and logging in the coastal silver fir zone will alter habitat by removing substrate and altering microclimate, and may put the species at risk. Air pollution would also be a serious threat because of interception of aerosols on high, fog-bound peaks favored by *Iwatsukiella.* Overcollecting is also a threat, because known populations are so restricted, and the species is a sought-after rarity.



Iwatsukiella leucotricha. -- 1. Plant, about natural size. -- 2. Leaves. -- 3. Cells in middle of leaf. -- 4. Cells in alar region at base of leaf. -- 5. Cells at tip of leaf. -- 6. Capsule. -- 7. Peristome. -- 8. Perichaetial leaf. From Noguchi (1991). Reprinted with permission of the Hattori Botanical Laboratory.

LIMBELLA FRYEI (Williams) Ochyra
Frye's swamp moss
Recent synonym: *Sciaromium tricostatum* (Sull.) Mitt. *in* Seem. for North American records.



Status: FWS SoC; ODA C; ONHP List 1.

Distribution: Endemic to the Pacific Northwest. Coastal Oregon.

Habitat and ecology: Forming sods to 3 feet in diameter, on wet rotten wood, leaf litter and lower trunks of tall shrubs, in dense coastal shrub swamps. Associated vascular species include *Pyrus fusca, Salix hookeriana, Salix sitchensis, Carex obnupta* and *Lysichiton americanum.* Associated mosses include *Neckera douglasii, Orthotrichum lyallii, Eurhynchium praelongum, Leucolepis acanthoneuron,* and *Rhizomnium glabrescens.* The shrubs may be festooned with the lichen *Usnea longissima.* The population at the type locality, now apparently extinct, was described as "more or less wet pasture", but no new populations of *Limbella* have been found in pasture. It may tolerate considerable light, but substrate must be seasonally wet. Mats form habitat for caddisfly larvae, snails, small bivalves, mites and other invertebrates.

Description: Plants dendroid or sometimes trailing, yellow-green to dark green. Stems dark brown, 4-13 cm long, with densely matted dark reddish-brown rhizoids at base. Leaves with a midrib and thickened margins, toothed at the tip and sometimes to the base, contorted when dry, tapering gradually to the tip, or often almost parallel-sided and then tapering rather abruptly at the tip.

Distinctive characters: (1) Dendroid moss with dark stems, (2) strong midrib and thickened margins visible with a hand lens as three parallel lines. The teeth can also be seen with a lens.

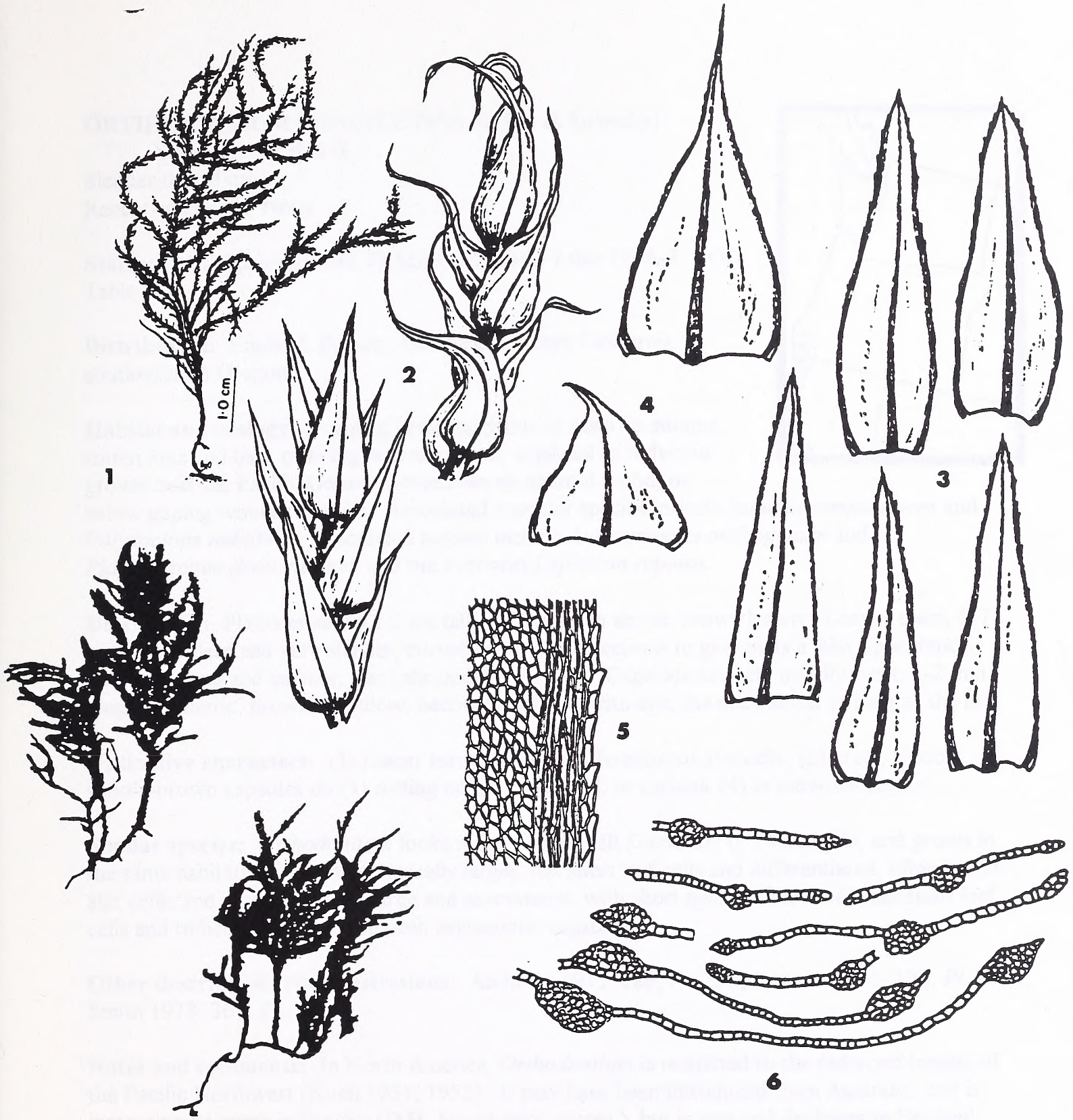
Similar species: *Leucolepis acanthoneuron* has dark green, fine-textured, toothed leaves that are much smaller and more crowded than those of *Limbella*, and they lack thickened margins. *Climacium dendroides* is light green and coarse-textured, with large concave leaves that are rounded at the tips, but lacking obvious teeth and thickened margins. Its orange-brown stems are visible through wet leaves, and are 4-8 cm long. *Pleuroziopsis ruthenica* has yellow-green, fine-textured leaves, and greenish-brown stems up to 15 cm tall, with conspicuous scales sheathing the stem below the branches. *Thamnobryum neckeroides* has irregular branching, remote stem leaves and leaves keeled near the shoot tips.

Other descriptions and illustrations: Williams 1933: 52; Grout 1934: 266, *Pl. 80*; Lawton 1971: 287, *Pl. 158*; Christy 1987: *396*, 408; Ochyra 1987: 477, *478, 479.*

Notes and comments: The largest known population of *Limbella* occurs at Sutton Lake Swamp Preserve, and a few smaller populations occur elsewhere around the lake. It has been sought

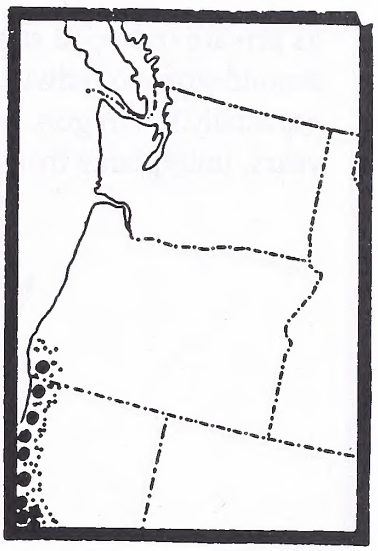
extensively along the coast from northern California to British Columbia, but no new localities have been found.

Conservation issues: Housing development, water pollution, earthquake-related subsidence, and human-caused changes in hydrology are the primary threats. Development of lakefront property, and associated problems with septic fields, would destroy habitat for *Limbella*. Flooding caused by damming or tectonic subduction could inundate the habitat and wipe out the population. Local zoning and a citizens lake watch program, with lakefront homeowner participation, would be a good way to safeguard development and water quality issues. Transplantation to other sites may be advisable to safeguard the species from loss due to catastrophic events at Sutton Lake.



Limbella fryei. -- 1. Plants. -- 2. Detail of shoots, wet and dry. -- 3. Branch leaves. -- 4. Stem leaves. -- 5. Cells at margin of branch leaves, showing band of thickened cells. -- 6. Cross-section of leaves, showing thickened costa and margins. From Ochyra (1987) and Christy (1987). Reprinted with permission of Ryszard Ochyra, the British Brylogical Society, and the Hattori Botanical Laboratory.

ORTHODONTIUM GRACILE (Wils. *in* Sm. & Sowerby) Schwaegr. *ex* B.S.G.
Slender thread moss
Recent synonyms: None



Status: SAT Appendix 5-H; FEMAT Appendix Table IV-A-3; ROD Table C-3.

Distribution: England, France, Australia, northern California, southwestern Oregon.

Habitat and ecology: Forming dense cushions or mats on stumps, rotten logs and bark of living redwood trees, confined to redwood groves near the Pacific Ocean. Sometimes on charred wood, or below gaping wounds in trees. Associated vascular species include *Sequoia sempervirens* and *Polystichum munitum*. Associated mosses include *Aulacomnium androgynum* and *Plagiothecium denticulatum*, and the liverwort *Lepidozia reptans.*

Description: Plants erect, to 1.2 cm tall, yellow-green above, brown below. Leaves erect, 5-7 mm long, linear and very slender, curved in various directions to give mats a felty appearance. Leaf cells long and narrow, alar cells undifferentiated. Capsules smooth, usually erect, 1-2 mm long, symmetric, brownish yellow, becoming whitish with age, the neck about as long as the urn.

Distinctive characters: (1) Linear leaves without differentiated alar cells, (2) erect, smooth yellow-brown capsules on (3) rotting or charred wood, or on bark (4) in redwood region.

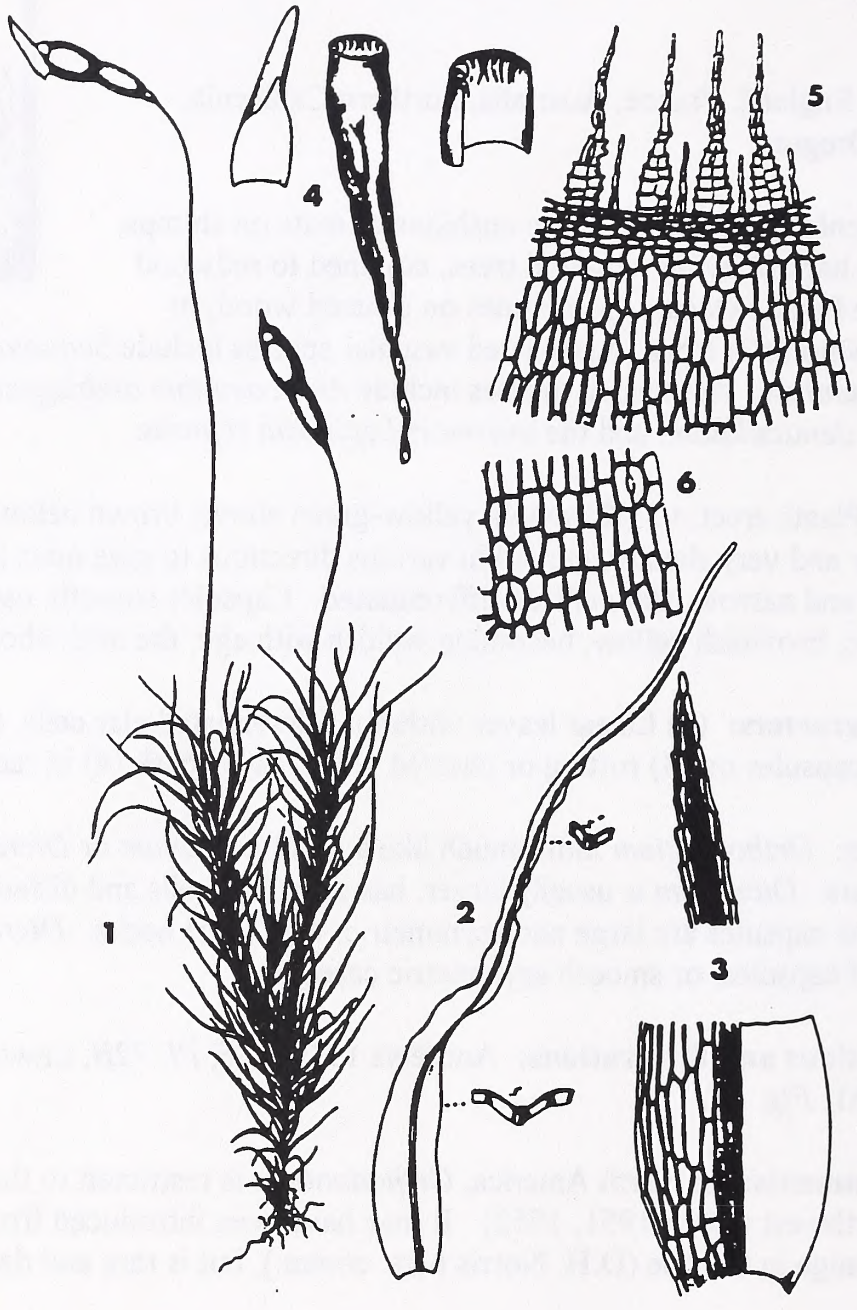
Similar species: *Orthodontium* looks much like a small *Dicranum* or *Dicranella*, and grows in the same habitats. *Dicranum* is usually larger, has short leaf cells and differentiated, often brown alar cells, and its capsules are large and asymmetric, with short necks. *Dicranella* has short leaf cells and ribbed capsules, or smooth asymmetric capsules.

Other descriptions and illustrations: Andrews 1935: 186, *Pl. 72B*; Lawton 1971: 178, *Pl. 97*; Smith 1978: 361, *Fig. 171.*

Notes and comments: In North America, *Orthodontium* is restricted to the redwood forests of the Pacific Northwest (Koch 1951, 1952). It may have been introduced from Australia, and is increasing its range in Europe (D.H. Norris pers. comm.), but is rare and declining in England (Smith 1978).

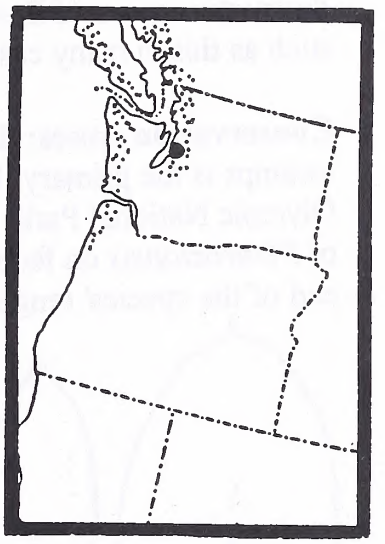
Conservation issues: In the Pacific Northwest, the major threat to *Orthodontium* is logging of redwood forests. Norris (1987) reported that it was more abundant in old-growth redwood forest than in 100-year-old second-growth, indicating that old-growth provides optimal habitat for this species. Redwoods at the site in Oregon reported by Koch were later logged, and the species may no longer occur in the state. The best opportunities for protection will be on federal lands,

as private redwood stands will be logged. Surveys should be conducted in old-growth and second-growth redwood stands to determine abundance and distribution of the species, especially in Oregon. Roading, logging and slash burning would destroy habitat for up to 50 years, until plants from adjacent stands could repopulate sites.



Orthodontium gracile. -- 1. Plant and capsules. -- 2. Leaf and cross-sections of leaf. -- 3. Cells at tip and base of leaf. -- 4. Capsule and calyptra. -- 5. Peristome and cells below mouth of capsule. -- 6. Cells on capsule, showing stomata. From Andrews (1935).

PLEUROZIOPSIS RUTHENICA (Wienm.) Kindb. *ex* Britt.
Grand palm moss
Recent synonyms: None



Status: SAT Appendix 5-H; FEMAT Appendix Table IV-A-3; ROD Table C-3

Distribution: Japan, Russian Far East, Alaska, British Columbia, Washington

Habitat and ecology: Forming carpets on wet organic soils, rotten wood and bark in low-elevation shrub thickets, old-growth cedar or Sitka spruce swamps, and at the edge of streams and lakes. It usually occurs on floodplains, but is also known from wet cliffs. Associated mosses include *Hookeria lucens, Rhytidiadelphus loreus, Plagiomnium insigne* and *Eurhynchium praelongum*.

Description: Plants erect, large and dendroid, to 12 cm long. Stems closely and completely sheathed most of their length with large (to 4 x 3.2 mm), blunt, green to copper-colored shiny leaves, the stems looking like shiny cylinders. Clusters of brown rhizoids occur beneath the stem leaves. Branches terminal, in a dense flat-topped cluster, regularly pinnate, resembling a shaggy palm tree, with branched filamentous paraphyllia. Branch leaves small, slightly crisped when dry, bright yellow-green, serrate at tips. Capsules rare.

Distinctive characters: (1) Long stems, to 12 cm, (2) completely sheathed with large, smooth, shiny leaves most of the length, with (3) pinnate branching.

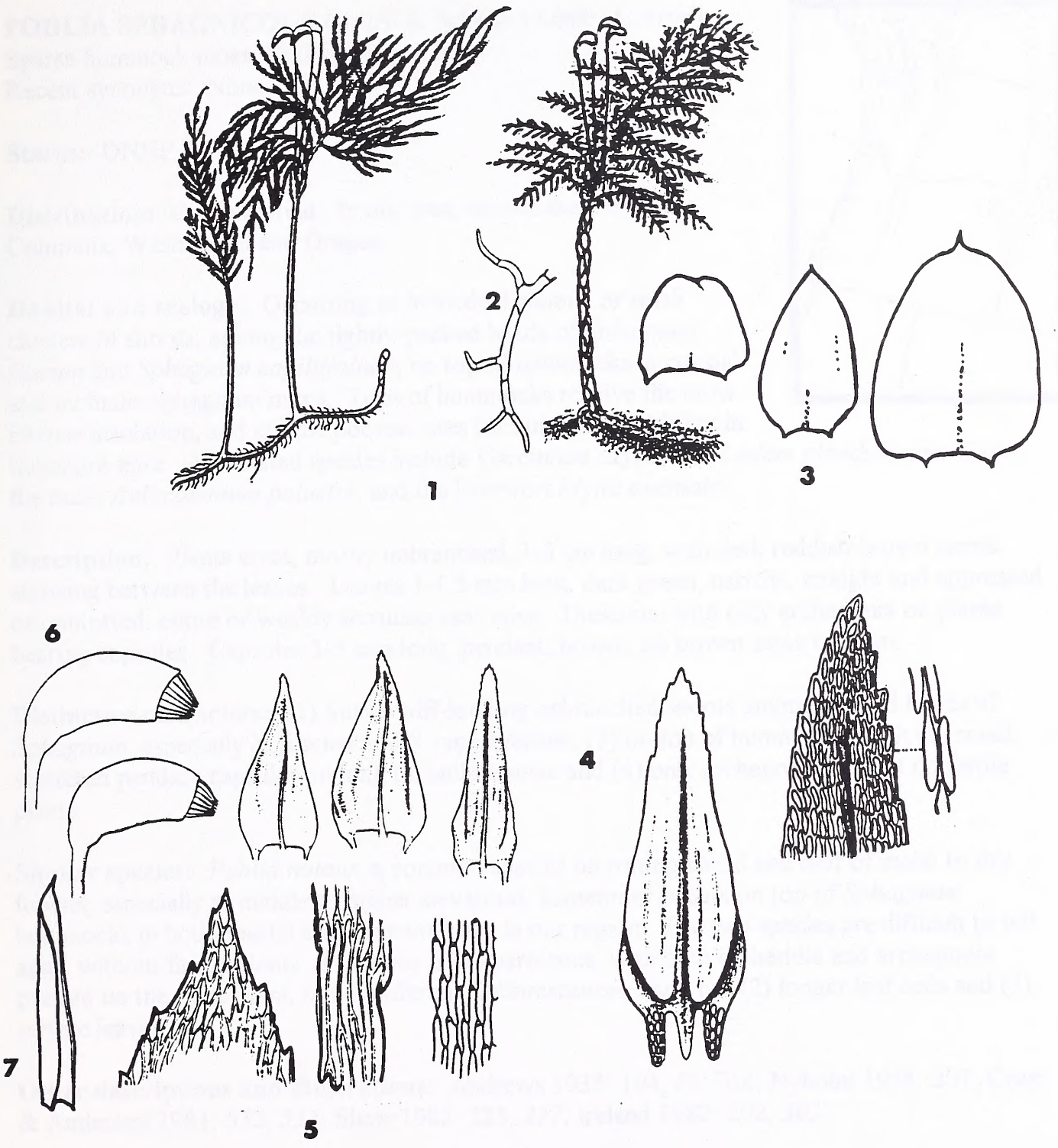
Similar species: *Climacium dendroides, Leucolepis acanthoneuron, Limbella fryei* and *Thamnobryum neckeroides* all have an erect, dendroid habit and grow in similar wet habitats. *Climacium* has (1) thick, turgid branches to 2 mm wide, (2) simple or irregular branching, (3) concave, blunt branch leaves without serrate margins, that are longitudinally striate but seldom crisped when dry and (4) orange branches showing through the yellowish leaves, especially when plants are wet. *Leucolepis* has (1) simple or irregular branching and (2) remote stem leaves, revealing a brownish-black stem with scattered rhizoids. *Limbella* has (1) distinctly thickened leaf margins and (2) remote stem leaves. *Thamnobryum neckeroides* has (1) irregular branching, (2) remote stem leaves and (3) leaves keeled near the shoot tips.

Other descriptions and illustrations: Brotherus 1909: 735; Grout 1928: 6, *Pl. 1*; Lawton 1971: 236, *Pl. 130*; Noguchi 1994: 1211.

Notes and comments: Only one collection of *Pleuroziopsis* is known from south of the Canadian border, collected on Puget Sound in Seattle at the turn of the century. Although correctly identified, some bryologists doubt that it really came from Puget Sound, which is far south of its present range. However, our region's flora had many surprises prior to the

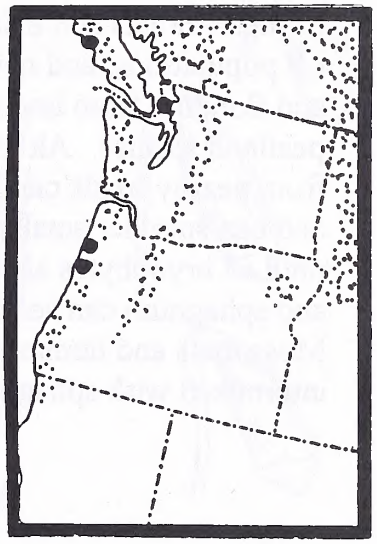
destructive wave of European settlement, evidenced by a few historical collections. Records such as this in many cases are real vestiges of a vanished landscape.

Conservation issues: Logging of coastal Sitka spruce, red cedar or Alaska yellow cedar swamps is the primary threat to this species. Searches should be conducted along the coast in the Olympic National Park, and on nearby tribal and state DNR lands. Protection of any populations of *Pleuroziopsis* on federal lands would also protect possibly unique genotypes at the southern end of the species' range.



Pleuroziopsis ruthenica. -- 1. Plants with capsules. -- 2. Detail of paraphyllia. -- 3. Stem leaves. -- 4, 5. Branch leaves, showing cells at tip, middle and in alar region. -- 6. Capsules. -- 7. Perichaetial leaf. From Brotherus (1909) and Noguchi (1994). Figures from Noguchi (1994) reprinted with permission of the Hattori Botanical Laboratory.

POHLIA SPHAGNICOLA (Bruch & Schimp.) Lindb. & Arnell
Sparse hummock moss, Nodding bog moss
Recent synonyms: None



Status: ONHP List 2.

Distribution: Circumboreal. In our area, known from British Columbia, Washington and Oregon.

Habitat and ecology: Occurring as individual shoots, or small clusters of shoots, among the tightly-packed heads of *Sphagnum fuscum* and *Sphagnum capillifolium*, on top of hummocks in coastal and montane sphagnum mires. Tops of hummocks receive the most intense insolation, and are the poorest sites for nutrient availability in the entire mire. Associated species include *Vaccinium oxycoccos, Ledum glandulosum, Carex,* the moss *Aulacomnium palustre,* and the liverwort *Mylia anomala.*

Description: Plants erect, mostly unbranched, 1-3 cm long, with dark reddish-brown stems showing between the leaves. Leaves 1-1.5 mm long, dark green, narrow, straight and appressed or contorted, entire or weakly serrulate near apex. Dioicous, with only archegonia on plants bearing capsules. Capsules 3-5 mm long, pendant, brown, on brown setae to 3 cm.

Distinctive characters: (1) Small, stiff-looking unbranched shoots among packed heads of *Sphagnum*, especially *S. fuscum* and *S. capillifolium,* (2) on top of hummocks, with (3) small, scattered pendant capsules on long threadlike setae and (4) only archegonia present on fertile plants.

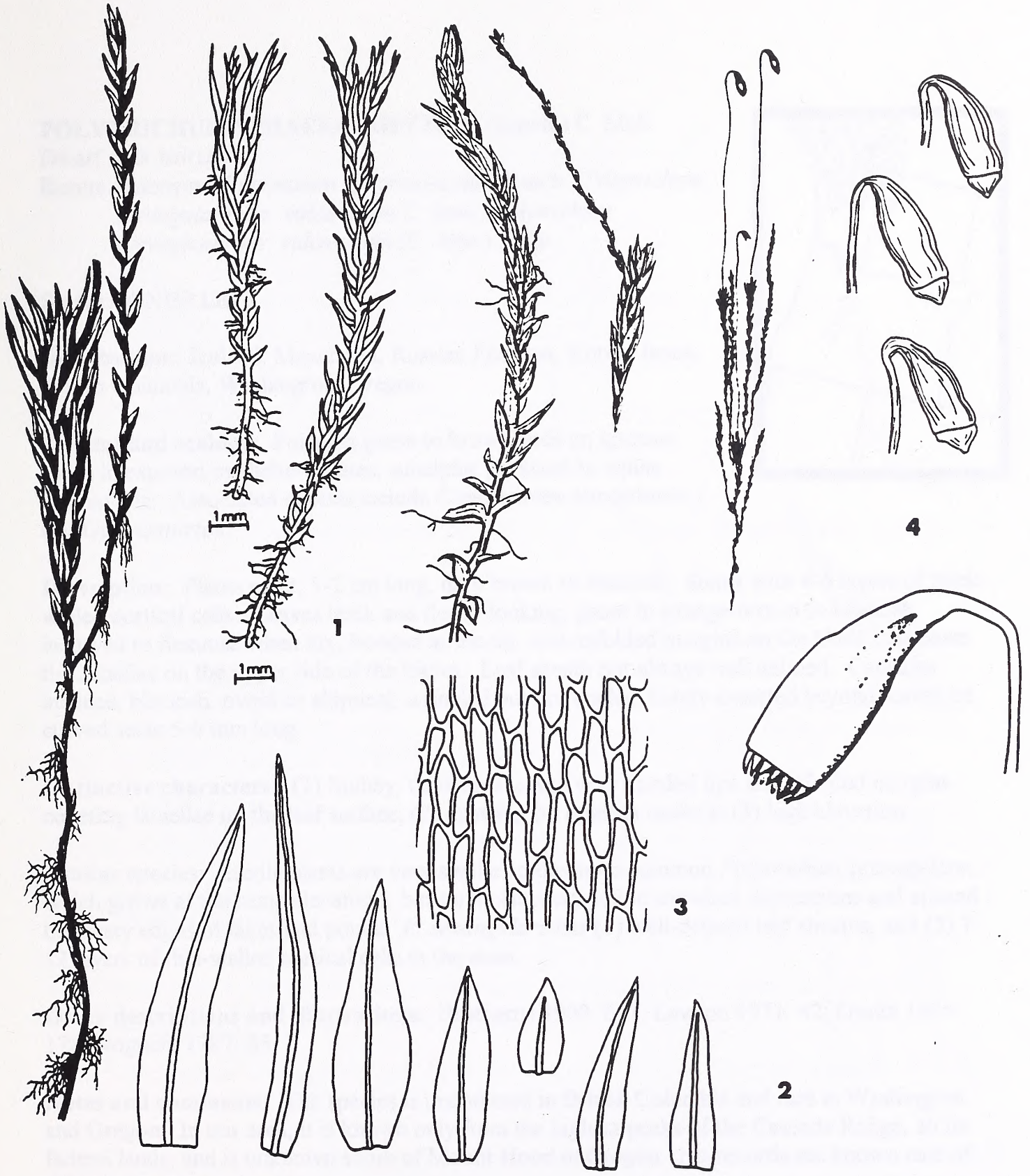
Similar species: *Pohlia nutans*, a common species on rotting wood and duff of moist to dry forests, especially at middle to higher elevations, sometimes occurs on top of *Sphagnum* hummocks in both coastal and montane bogs in our region. The two species are difficult to tell apart without fertile plants. *P. nutans* is (1) paroicous, with both antheridia and archegonia present on the same plant, but in different "inflorescences," and has (2) longer leaf cells and (3) serrate leaves.

Other descriptions and illustrations: Andrews 1935: 194, *Pl. 76A*; Nyholm 1958: 207; Crum & Anderson 1981: 532, *533*; Shaw 1982: 225, *227*; Ireland 1982: 292, *302*.

Notes and comments: Rare throughout its range. Restricted to *Sphagnum* hummocks, but much less common than *P. nutans.* Some think *P. sphagnicola* is only a poorly-developed form of *P. nutans*, but careful studies (Shaw 1982) have shown the differences to be consistent.

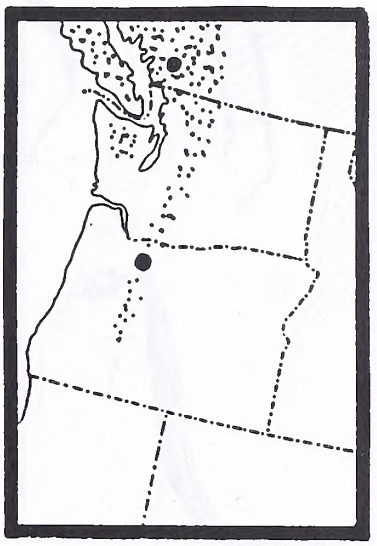
Conservation issues: Peatlands are fragile ecosystems that need protection. Over the last 100 years, those in our area have been impacted by grazing, water diversion and impoundment, drainage projects, road construction, and commercial harvest of peat and sphagnum moss. Most

of these threats still exist today. All known localities should be searched to reconfirm presence of populations, and new populations need to be found. Dewatering from drainage or diversion, and flooding from impoundment cause replacement of plant communities and disappearance of peatland species. Although federal regulations prohibit building new roads in wetlands, dust from nearby roads can have a significant impact on the nutrient status of wetlands, can alter pH, and can smother small plants such as bryophytes. Livestock may trample and churn peatland until all bryophytes are destroyed, especially around water holes. Commercial collecting of peat and sphagnum can seriously deplete bryophyte diversity in mires, especially on hummocks. Moss mats and hummocks are destroyed during collection, and tiny hummock-dwelling species intermixed with sphagnum moss may take many years to recover.



Pohlia sphagnicola. -- 1. Plants; those on far right about natural size. -- 2. Leaves. -- 3. Cells in middle of leaf. -- 4. Capsules, with and without operculum. From Andrews (1935), Crum and Anderson (1981), Shaw (1982) and Ireland (1982). Figures from all but Andrews (1935) reprinted with permission of Columbia University Press, Jonathan Shaw, the University of Michigan Herbarium, and the Canadian Museum of Nature, Ottawa.

POLYTRICHUM SPHAEROTHECIUM (Besch.) C. Müll.
Dwarf rock haircap
Recent synonyms: *Pogonatum sphaerothecium* Besch.; *Polytrichum sexangulare* var. *vulcanicum* C. Jens.; *Polytrichum norvegicum* var. *vulcanicum* (C. Jens.) Podp.



Status: ONHP List 3.

Distribution: Iceland, Manchuria, Russian Far East, Korea, Japan, British Columbia, Washington, Oregon.

Habitat and ecology: Forming green to brown sods on igneous rocks in exposed or sheltered sites, subalpine parkland to alpine krummholz. Associated species include *Conostomum tetragonum* and *Gymnomitrion*.

Description: Plants erect, 1-2 cm long, dark brown to blackish. Stems with 4-6 layers of thick-walled cortical cells. Leaves thick and fleshy-looking, green to orange-brown to blackish, incurved to flexuose when dry, hooded at the tip, with infolded margins on the blade that cover the lamellae on the upper side of the leaves. Leaf sheath not always well defined. Capsules inclined, blackish, ovoid or elliptical, wrinkled but not angled, barely exserted beyond leaves on curved setae 5-6 mm long.

Distinctive characters: (1) Stubby, thickened leaves with hooded tips and infolded margins covering lamellae on the leaf surface, (2) growing on igneous rocks at (3) high elevation.

Similar species: Sterile plants are very similar to the more common *Polytrichum sexangulare*, which grows at the same elevations, but on moist peaty soil in snowbed depressions and around the peaty edges of lakes and ponds. *P. sexangulare* has (1) well-defined leaf sheaths, and (2) 7-12 layers of thin-walled cortical cells in the stem.

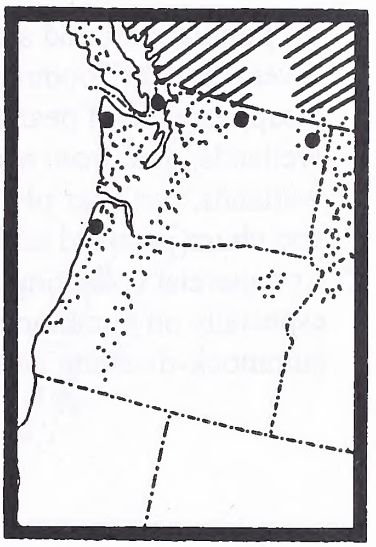
Other descriptions and illustrations: Brotherus 1909: 691; Lawton 1971: 42; Osada 1965: 178; Noguchi 1987: 45.

Notes and comments: The species is uncommon in British Columbia and rare in Washington and Oregon. In our area, it is known only from the highest peaks of the Cascade Range, all on federal lands, and is unknown south of Mount Hood in Oregon. No records are known east of the Cascade Range.

Conservation issues: Mountain climbing and development of trails and ski runs may threaten some populations locally. Air pollution and climate change may also be threats. This species should be sought in high-elevation sites. Protection of known sites from recreational activities, particularly alpine hiking and rock climbing, will minimize risk to populations.

Polytrichum sphaerothecium. -- 1, 3. Plants with capsules, with and without operculum; plants at upper left about natural size. -- 2. Leaves, showing lamellae on upper surface, and infolded margins forming hood at tip of leaf. -- 4. Cross-section of leaves, showing lamellae on upper surface, and infolded margins of leaf. --. 5. Cross-section of leaf, showing detail of lamellae. From Brotherus (1909), Osada (1965) and Noguchi (1987). Figures from all but Brotherus (1909) reprinted with permission of the Hattori Botanical Laboratory.

POLYTRICHUM STRICTUM Brid.
Hummock haircap, Slender haircap, Narrow-leaved haircap
Recent synonym: *Polytrichum juniperinum* var. *affine* (Funck) Brid.



Status: ONHP List 2.

Distribution: Circumboreal and bipolar; in the Pacific Northwest, known from British Columbia, Alberta, Montana, Washington, Oregon.

Habitat and ecology: Plants scattered individually or forming loose turfs on organic soils, particularly on top of *Sphagnum* hummocks, in coastal and montane mires. The tops of hummocks are subject to intense insolation, and are nutrient poor. Associated species include *Vaccinium oxycoccos, Ledum glandulosum, Carex,* and the mosses *Sphagnum* and *Aulacomnium palustre.*

Description: Plants erect, 1-10 cm tall, mostly unbranched, felted between the leaves, sometimes very densely, with whitish rhizoids. Leaves awl-shaped, green, bluish-green to reddish brown, with reddish-brown tips, 4-8 mm long, stiffly appressed when dry, spreading when moist, with margins infolded, covering the lamellae on the upper surface of the leaves. Setae brown, 2-6 cm long. Capsules brown, 2-5 mm long, square in cross-section. Peristome membranous like the head of a drum, not composed of teeth.

Distinctive characters: Robust, erect mosses with stiff, awl-shaped leaves having lamellae on the upper leaf surface will place you in the genus *Polytrichum*. *P. strictum* is the only species (1) growing on organic soils, particularly on top of *Sphagnum* hummocks, with (2) overlapping leaf margins that hide the lamellae. The overlapping margins can be seen with a hand lens as a fine line running down the center of the leaf surface.

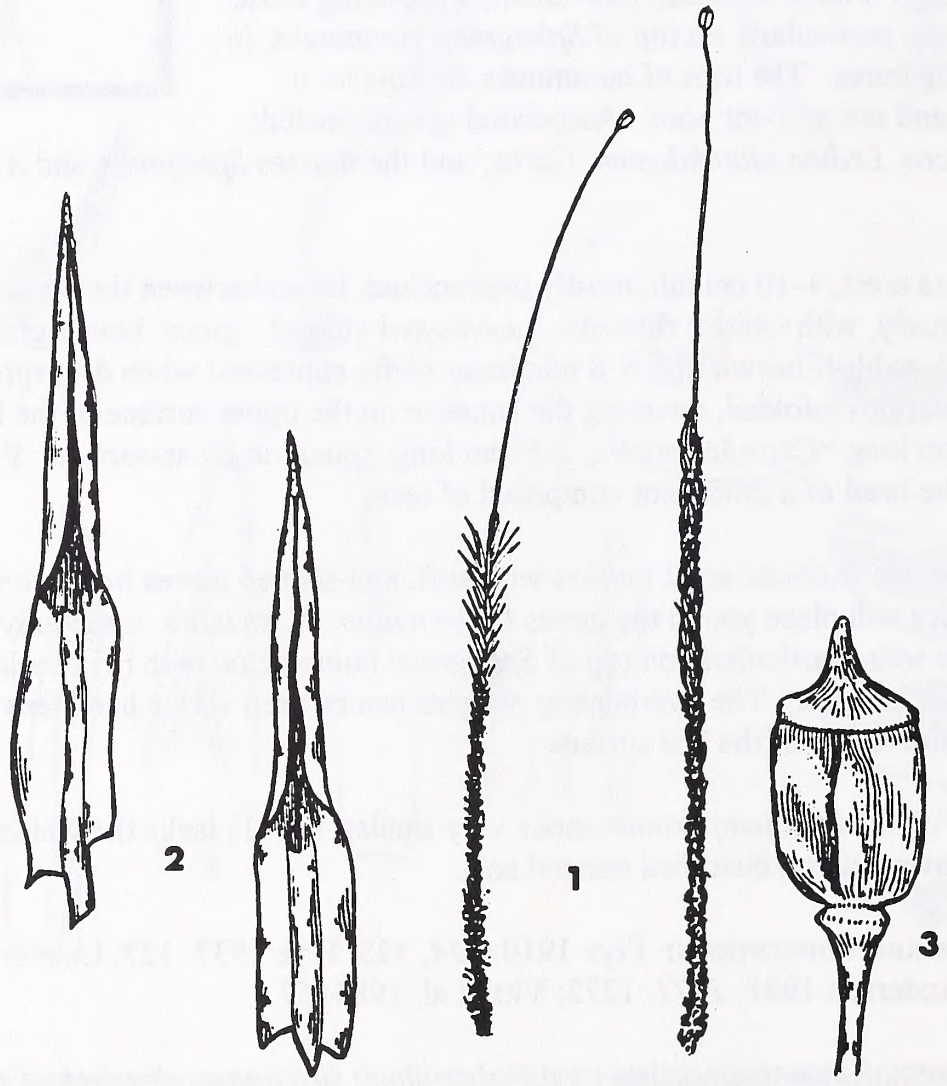
Similar species: *Polytrichum juniperinum* looks very similar, but (1) lacks the whitish felty rhizoids and (2) grows only on disturbed mineral soil.

Other descriptions and illustrations: Frye 1910: *324*, 325; Frye 1937: 127; Lawton 1971: 42, *Pl. 10*; Crum and Anderson 1981: *1271*, 1272; Vitt et al. 1988: 57.

Notes and comments: Some taxonomists treat *Polytrichum strictum* as a variety of *P. juniperinum*, but the ecology of the two species is distinctly different. *P. strictum* grows on sphagnum and peat, while *P. juniperinum* grows on disturbed mineral soil.

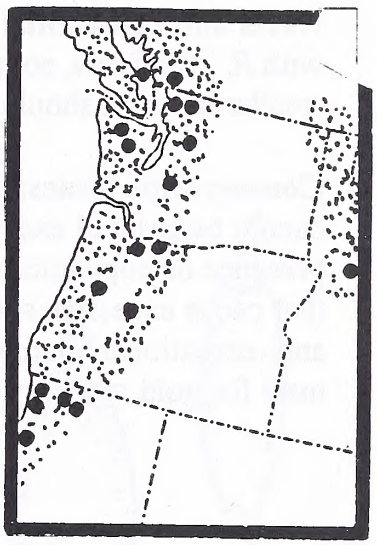
Conservation issues: Peatlands are fragile ecosystems that need protection. Over the last 100 years, those in our area have been impacted by grazing, water diversion and impoundment, drainage projects, road construction, and commercial harvest of peat and sphagnum moss. Most of these threats still exist today. All known localities should be searched to reconfirm presence

of populations, and suitable habitat surveyed for new populations. Dewatering from drainage or diversion, and flooding from impoundment cause replacement of plant communities and disappearance of peatland species. Although federal regulations prohibit building new roads in wetlands, dust from nearby roads can have a significant impact on the nutrient status of wetlands, can alter pH, and can smother small plants such as bryophytes. Livestock may trample and churn peatland until all bryophytes are destroyed, especially around water holes. Commercial collecting of peat and sphagnum can seriously deplete bryophyte diversity in mires, especially on hummocks. Moss mats and hummocks are destroyed during collection, and tiny hummock-dwelling species intermixed with sphagnum moss may take many years to recover.



Polytrichum strictum. -- 1. Plants with capsules, wet and dry. -- 2. Leaves, showing lamellae on upper surface, and infolded margins of leaves that cover lamellae toward tip of leaf. -- 3. Capsule. From Crum and Anderson (1981). Reprinted with permission of Columbia University Press.

RACOMITRIUM AQUATICUM (Brid. *ex* Schrad.) Brid.
Awnless wet wavy-cell moss
Recent spelling: *Rhacomitrium aquaticum*
Recent synonyms: None



Status: FEMAT Appendix Table IV-A-3; ROD Table C-3.

Distribution: Circumboreal and bipolar. In the Pacific Northwest, known from Alaska, British Columbia, Alberta, Washington, Oregon and California.

Habitat and ecology: Forming mats on shaded, moist rocks and cliffs along shady streams or in forests, often in the splash zone, but never aquatic. Associated species may include *Scouleria aquatica, Racomitrium aciculare* and *Scleropodium obtusifolium.*

Description: Plants decumbent to erect, 1-10 cm long, branched irregularly. Leaves green, yellow-green to blackish below, straight or falcate at shoot tips, imbricate when dry, 2-4 mm long, 0.4-1 mm wide, tapered to a rounded tip, with margins entire. Costa forming prominent keel at back of leaf, ending before the leaf tips, never forming an awn, with leaf margins recurved. Leaf cells multipapillose, the cell walls sinuose-wavy. Setae 4-8 mm long, twisted clockwise when dry. Capsules 2-3 mm long, cylindrical. Peristome teeth 0.5 mm long.

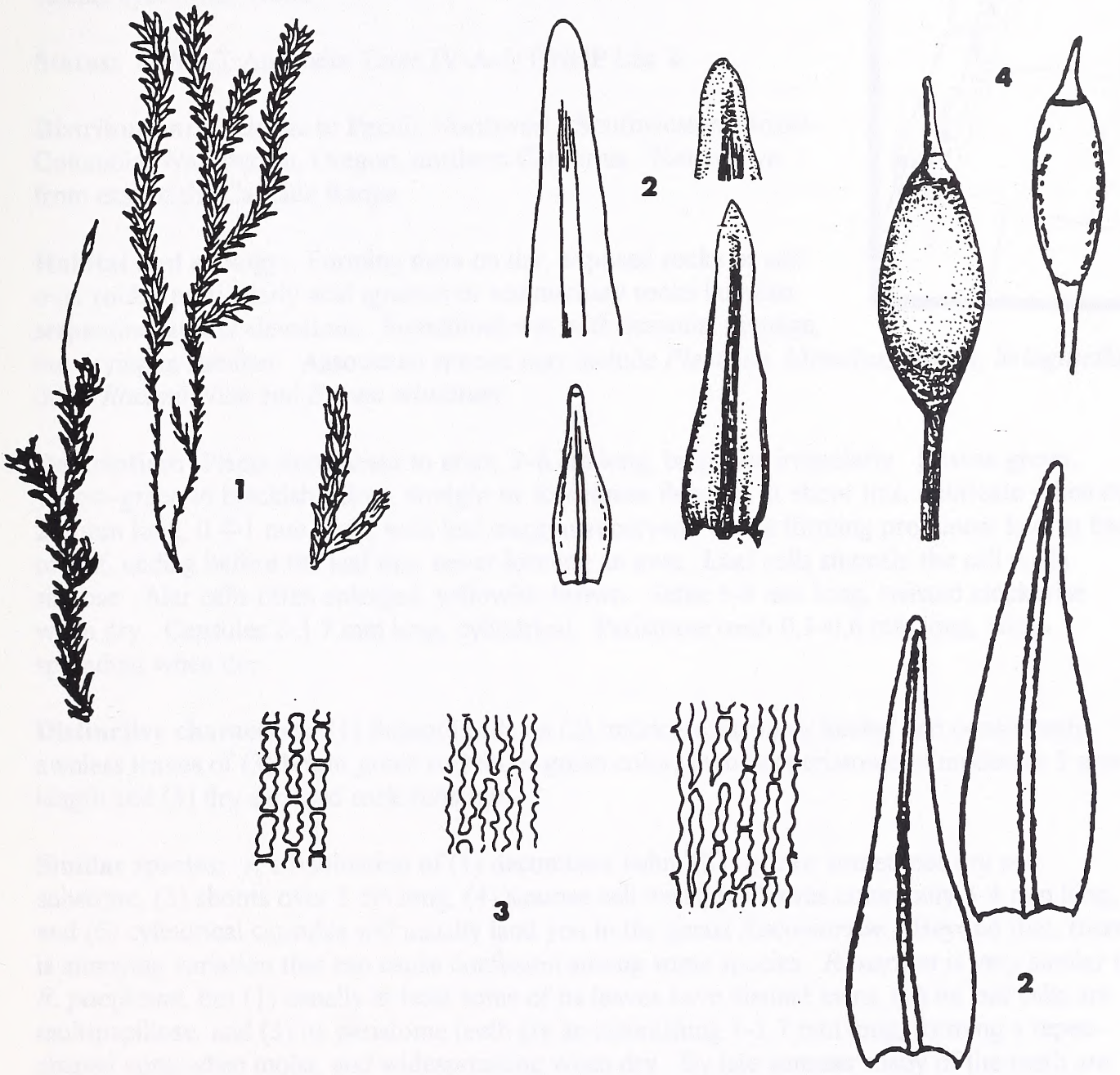
Distinctive characters: (1) Multipapillose cells on (2) imbricate, strongly keeled and consistently awnless leaves of (3) bright green to yellow-green color, (4) peristome of moderate 1 mm length and (5) moist shaded rock substrate.

Similar species: A combination of (1) decumbent habit, (2) rock or sometimes dry soil substrate, (3) shoots over 3 cm long, (4) sinuose cell walls, (5) leaves commonly 3-4 mm long, and (6) cylindrical capsules will usually land you in the genus *Racomitrium*. Beyond that, there is annoying variation that can cause confusion among some species. *R. varium* is very similar to *R. aquaticum*, but (1) usually at least some of its leaves have distinct awns, (2) its peristome teeth are an astonishing 1-1.7 mm long, forming a tepee-shaped cone that is frequently broken, and (3) its habitat on rocks, logs and soil is usually drier than that of *R. aquaticum*. *R. pacificum* differs from *R. aquaticum* by its (1) smooth leaf cells and (2) dry rocky substrate. *R. heterostichum* and its segregates can often lack awns, but are distinguished from *R. aquaticum* by (1) a dirty, olive-green coloration, (2) smooth leaf cells, (3) presence of bistratose regions in the leaf blade and (4) dry habitat. *Dryptodon patens* has (1) prominent "fins" on the back of the costa, visible with a hand lens, (2) has only slightly sinuous cell walls, and (3) its seta is twisted counterclockwise when dry.

Other descriptions and illustrations: Jones 1933: 53; Nyholm 1956; 163; Watson 1968: 227, *228*; Lawton 1971: 142, *Pl. 74*; Smith 1978: 329, *330*; Noguchi 1988.

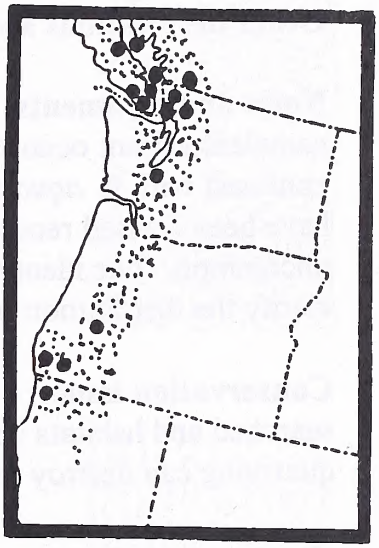
Notes and comments: Lawton (1971) considered this species to be rare. It has been confused with *R. pacificum*, so its distribution in the region is unclear. The identity of collections in smaller herbaria should be verified and annotated, to clarify the distribution of this species.

Conservation issues: Lower-elevation streams are usually privately owned, and protection cannot be assured except on federal lands. Known localities should be searched to reconfirm presence of populations, and suitable habitat surveyed for new populations. Upstream activities that cause excessive siltation could be detrimental to this species. Recreational gold dredging and recreational boating can also damage mosses in splash zones by abrasion or removal of moss mats for gold recovery.



Racomitrium aquaticum. -- 1. Plants with capsule, wet and dry. -- 2. Leaves and details of leaf tips. -- 3. Cells in upper, middle and lower parts of leaf. -- 4. Capsules with operculum. From Nyholm (1956), Watson (1968) and Smith (1978). Reprinted with permission of the Botanical Society of Lund, and Cambridge University Press.

RACOMITRIUM PACIFICUM Irel. & Spence
Awnless smooth dry wavy-cell moss
Recent spelling: *Rhacomitrium pacificum*
Recent synonyms: None



Status: FEMAT Appendix Table IV-A-3; ONHP List 2.

Distribution: Endemic to Pacific Northwest. Southwestern British Columbia, Washington, Oregon, northern California. Not known from east of the Cascade Range.

Habitat and ecology: Forming mats on dry, exposed rocks or soil over rocks, particularly acid igneous or sedimentary rocks but also serpentine, at low elevations. Sometimes wet with seasonal seepage, but drying in summer. Associated species may include *Plectritis, Mimulus, Sedum, Selaginella,* other *Racomitrium* and *Bryum miniatum*.

Description: Plants decumbent to erect, 2-6 cm long, branched irregularly. Leaves green, yellow-green to blackish below, straight or sometimes flexuose at shoot tips, imbricate when dry, 2-4 mm long, 0.4-1 mm wide, with leaf margins recurved. Costa forming prominent keel at back of leaf, ending before the leaf tips, never forming an awn. Leaf cells smooth, the cell walls sinuose. Alar cells often enlarged, yellowish-brown. Setae 5-8 mm long, twisted clockwise when dry. Capsules 2-3.7 mm long, cylindrical. Peristome teeth 0.3-0.6 mm long, wide-spreading when dry.

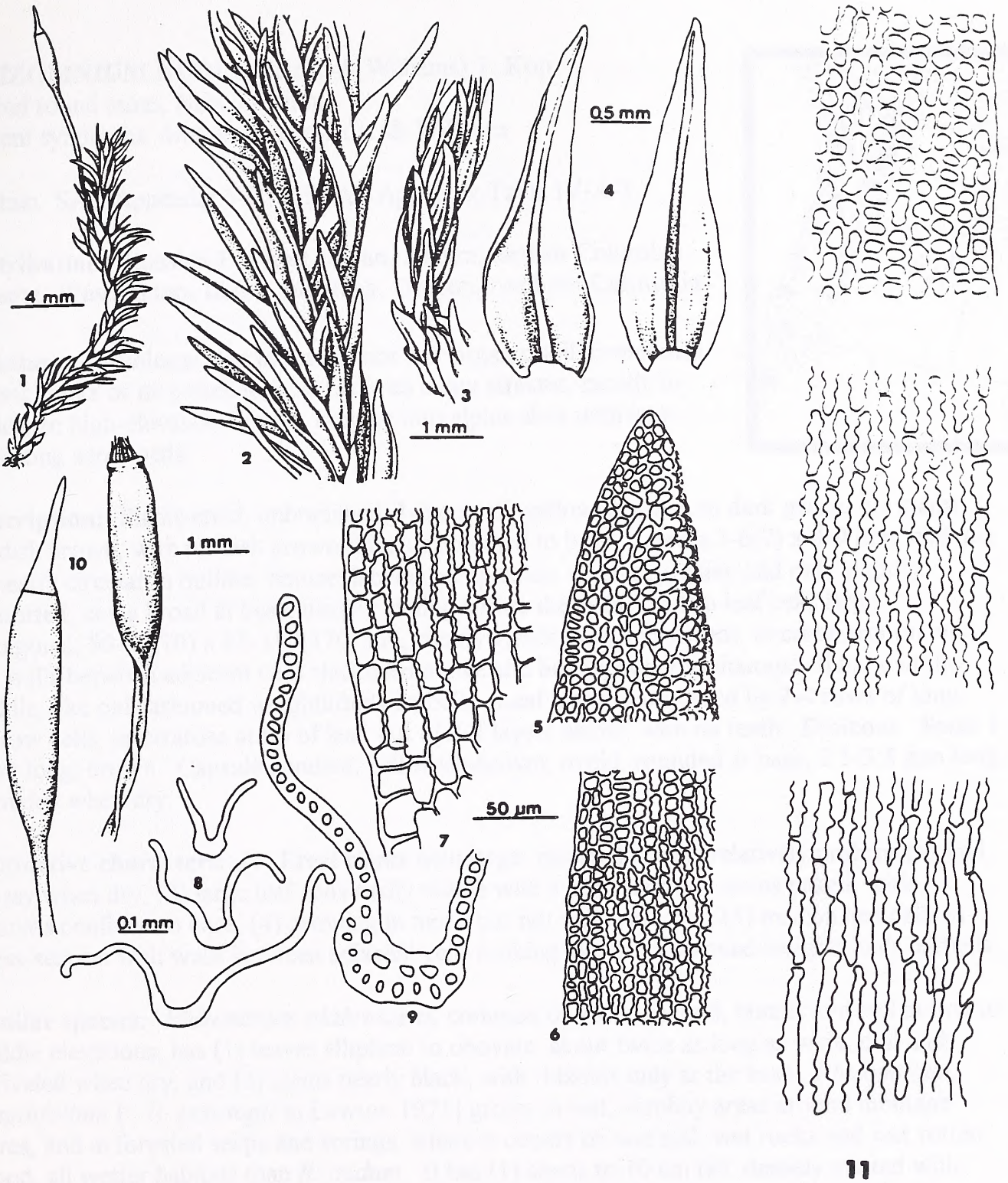
Distinctive characters: (1) Smooth cells on (2) imbricate, strongly keeled and consistently awnless leaves of (3) bright green to yellow-green color, with (4) peristome of moderate 1 mm length and (5) dry exposed rock substrate.

Similar species: A combination of (1) decumbent habit, (2) rock or sometimes dry soil substrate, (3) shoots over 3 cm long, (4) sinuose cell walls, (5) leaves commonly 3-4 mm long, and (6) cylindrical capsules will usually land you in the genus *Racomitrium*. Beyond that, there is annoying variation that can cause confusion among some species. *R. varium* is very similar to *R. pacificum*, but (1) usually at least some of its leaves have distinct awns, (2) its leaf cells are multipapillose, and (3) its peristome teeth are an astonishing 1-1.7 mm long, forming a tepee-shaped cone when moist, and widespreading when dry. By late summer many of the teeth are broken off. *R. aquaticum* differs from *R. pacificum* by its (1) multipapillose leaf cells and (2) moist rocky substrate. *R. aciculare* differs from *R. pacificum* by its (1) broadly rounded, blunt leaf tips with conspicuous teeth on the margins, (2) erect peristome teeth when dry, and (3) splash zone habitat, on wet or seasonally wet rocks. *R. heterostichum* and its segregates can often lack awns, but are distinguished from *R. pacificum* by (1) a dirty, olive-green coloration and (2) presence of bistratose regions in the leaf blade. *Dryptodon patens* has (1) prominent "fins" on the back of the costa, visible with a hand lens, (2) has only slightly sinuous cell walls, and (3) its seta is twisted counterclockwise when dry.

Other descriptions and illustrations: Ireland and Spence 1987: 860; Frisvoll 1988: 131.

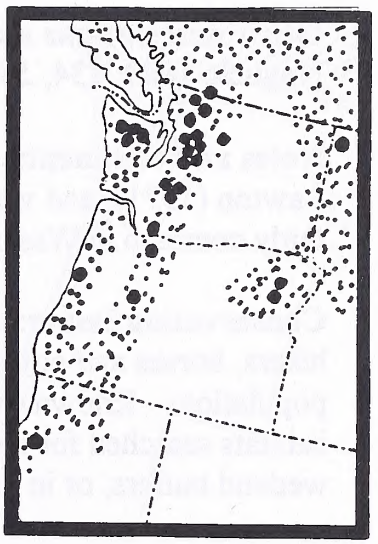
Notes and comments: This recently-described species had been recognized for years as a nameless variant occurring mostly in lowlands west of the Cascade Range. Although it has been confused with *R. aquaticum*, *R. varium* and *R. heterostichum*, most specimens in larger herbaria have been revised recently, and the number of correctly named specimens suggest that it is uncommon. The identity of collections in smaller herbaria should be verified and annotated, to clarify the distribution of this species.

Conservation issues: Threats include road building and quarrying. Outcrops should be searched and habitats characterized to help in finding additional populations. Road building and quarrying can destroy habitat for this species.



Racomitrium pacificum. -- 1. Plant with capsule. -- 2, 3. Detail of shoots, wet and dry. -- 4. Leaves. -- 5, 6, 7. Cells at tip, middle and base of leaf. -- 8. Cross-sections at tip, middle and base of leaf. -- 9. Detail of cross-section at base of leaf, showing absence of papillae. -- 10. Capsules, with and without operculum. 11. Cells at tip, middle and base of leaf. From Ireland and Spence (1987) and Frisvoll (1988). Reprinted with permission of the National Research Council of Canada, and the Museum of Natural History and Archaeology, Trondheim.

RHIZOMNIUM NUDUM (Britt. & Williams) T. Kop.
Naked round moss, Naked mnium
Recent synonyms: *Mnium nudum* Britt. & Williams



Status: SAT Appendix 5-H; FEMAT Appendix Table IV-A-3.

Distribution: Russian Far East, Japan, Alaska, British Columbia, Alberta, Washington, Idaho, Montana, Oregon, northern California.

Habitat and ecology: On moist but not wet organic soil, sometimes among rocks or on rotten logs, sometimes along streams, mostly in middle to high-elevation forests, ranging into alpine sites with late-persisting snow beds.

Description: Plants erect, unbranched, 1-5 cm tall, yellowish green to dark green, the stems reddish brown, with reddish brown rhizoids confined to base. Leaves 3-6(7) x 4-9 mm, obovate to nearly circular in outline, obtuse, lacking an apiculus; when dry, shiny and only slightly contorted; costa broad at base, usually ending before the apex; median leaf cells large, hexagonal, 50-60(70) x 85-150(170) μm, clearly visible with a hand lens, in cross-section with the walls between adjacent cells thickened above and below, but conspicuously thinner in the middle, like old-fashioned weightlifter's barbells. Leaf margins bordered by 2-4 rows of long, narrow cells, unistratose at tip of leaf, but of 2-4 layers below, with no teeth. Dioicous. Setae 1-3 cm long, brown. Capsule pendent, yellowish-brown, ovoid, rounded at base, 2.5-3.5 mm long, wrinkled when dry.

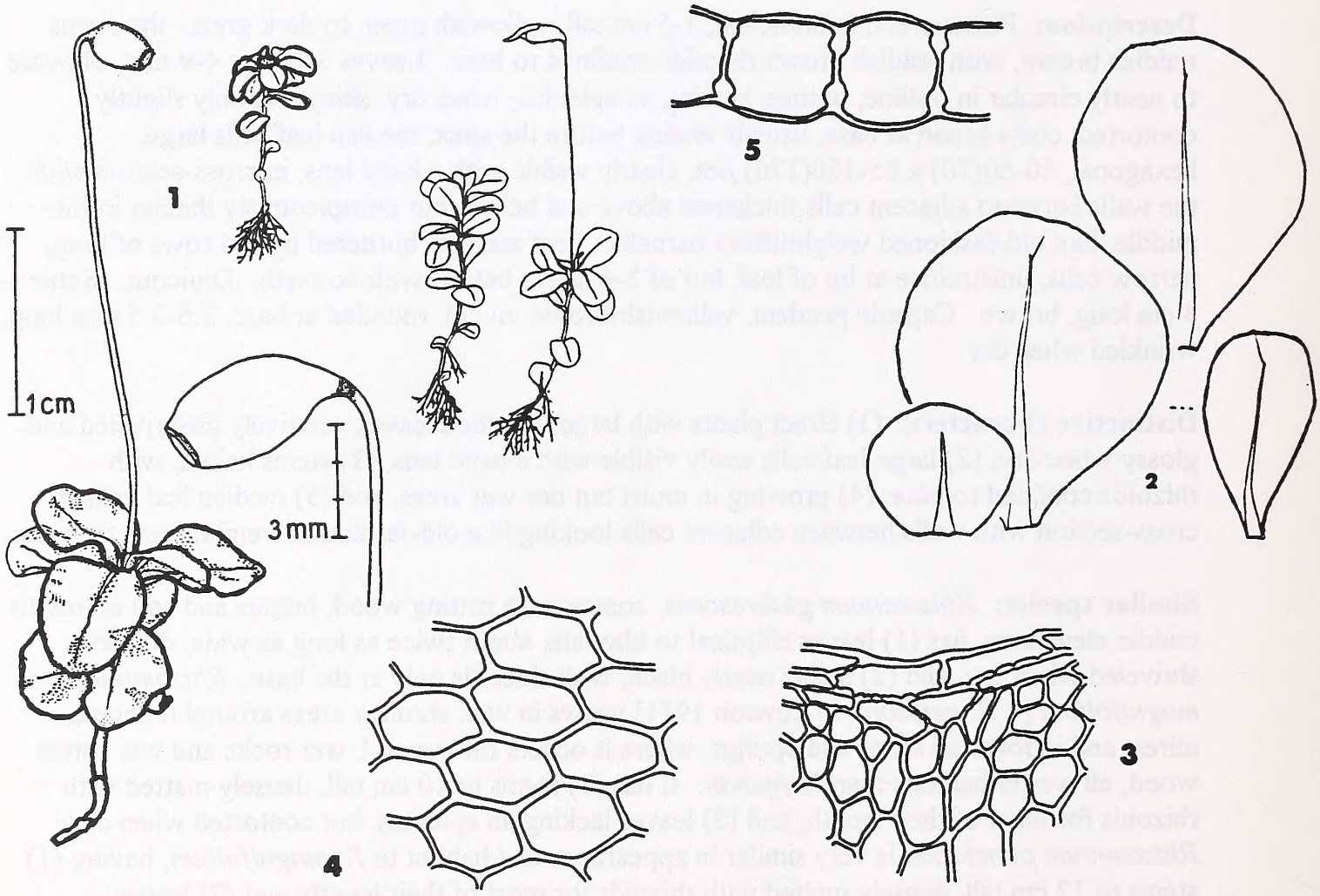
Distinctive characters: (1) Erect plants with large, rounded leaves, relatively unshriveled and glossy when dry, (2) large leaf cells easily visible with a hand lens, (3) stems naked, with rhizoids confined to base, (4) growing in moist but not wet areas, and (5) median leaf cells in cross-section with walls between adjacent cells looking like old-fashioned weightlifter's barbells.

Similar species: *Rhizomnium glabrescens,* common on rotting wood, humus and soil at low to middle elevations, has (1) leaves elliptical to obovate, about twice as long as wide, dull and shriveled when dry, and (2) stems nearly black, with rhizoids only at the base. *Rhizomnium magnifolium* [= *R. perssonii* in Lawton 1971] grows in wet, shrubby areas around montane mires, and in forested seeps and springs, where it occurs on wet soil, wet rocks and wet rotten wood, all wetter habitats than *R. nudum*. It has (1) stems to 10 cm tall, densely matted with rhizoids for most of their length, and (2) leaves lacking an apiculus, but contorted when dry. *Rhizomnium punctatum* is very similar in appearance and habitat to *R. magnifolium*, having (1) stems to 12 cm tall, densely matted with rhizoids for most of their length, and (2) leaves contorted when dry, but with a distinct apiculus. *Rhizomnium pseudopunctatum*, a small species of montane peatlands, has (1) leaves dull, contorted and incurved when dry, (2) stems densely matted with rhizoids for most of their length, and is (3) the only *Rhizomnium* in our area that is synoicous, having both antheridia and archegonia together in the same "inflorescence."

Other descriptions and illustrations: Lawton 1971: 199, *Pl. 110*; Koponen 1973: *7*, 8; Noguchi 1989: 534, *533*.

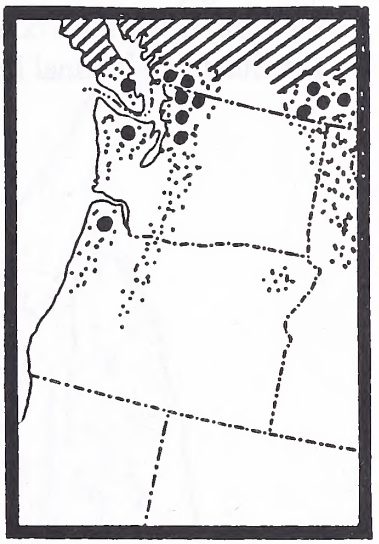
Notes and comments: Koponen's (1973) key for *Rhizomnium* is more complete than that of Lawton (1971), and was reproduced in Crum and Anderson (1981) on page 611. *R. nudum* is fairly common in Washington, but is rare in Oregon.

Conservation Issues: Damp, shaded sites are necessary for this species' survival. Trampling by hikers, horses and cows at stream crossings and watering holes could endanger some populations. Known sites should be checked to reconfirm presence of populations, and likely habitats searched for new populations. Populations may be adequately protected by stream and wetland buffers, or in designated wilderness areas.



Rhizomnium nudum -- 1. Plants. -- 2. Leaves. -- 3. Cells at tip of leaf. -- 4. Cells in middle of leaf. -- 5. Cross-section of cells from middle of leaf, showing barbell-shaped cross-walls. From Lawton (1971), Koponen (1973) and Noguchi (1989). Reprinted with permission of the Finnish Zoological and Botanical Publishing Board, and the Hattori Botanical Laboratory.

RHYTIDIUM RUGOSUM (Hedw.) Kindb.
Crumpled-leaf moss, Droop-branch moss, Beruffled moss
Recent synonyms: None



Status: ONHP List 3.

Distribution: Circumboreal, south to temperate South America and North Africa. In the Pacific Northwest, known from British Columbia, Alberta, Montana, Washington and Oregon.

Habitat and ecology: Forming loose mats over dry, exposed rocks or on dry soil, usually on the sloping sides and tops of dry bluffs and cliffs, at middle to higher elevations west of the Cascade Range. Sites subject to fog penetration. Associated species include *Sedum, Selaginella,* and other rock garden species, and the moss *Racomitrium canescens.*

Description: Plants ascending to trailing, shaggy, 3-10 cm long, irregularly to regularly pinnately branched, the branches 3-4 mm wide, looking swollen. Leaves crowded, yellow-brown, golden or copper colored, plainly wrinkled, falcate and secund, the branch tips having a hooked appearance. Costa single, margins recurved. Capsules rare.

Distinctive characters: (1) Robust habit, with stiff, hooked, irregularly pinnate branches, (2) wrinkled, golden-brown, falcate-secund leaves with (3) single costa and (4) dry, exposed habitat.

Similar species: *Rhytidium* resembles several large, shaggy creeping mosses in our area, all of which have wrinkled leaves. *Rhytidiadelphus triquetrus* has (1) yellow-green, widely spreading leaves, with double costae and pronounced longitudinal grooves, (2) regular pinnate branching without hooked tips, and (3) grows on duff and logs in cool lower-elevation forests, and also in open north-facing slopes over rocks and among grass. *Rhytidiopsis robusta* has (1) yellow-green falcate leaves with short double costae and pronounced longitudinal grooves, (2) spare or no branching and (3) grows on duff and logs in cool forests at middle to upper elevations.

Other descriptions and illustrations: Grout 1903: 269; Brotherus 1909: 1058; Grout 1932: 115; Nyholm 1965: 603; Lawton 1971: 331, *Pl. 195*; Crum and Anderson 1981: 1209, *1210*; Vitt et al. 1988: 110; MacKinnon et al. 1992: 300; Schofield 1992: 264, *265*.

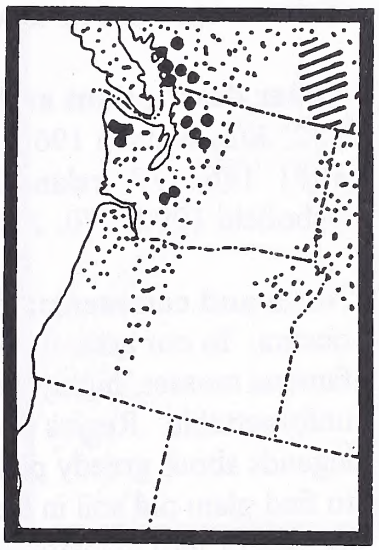
Notes and comments: A northern species, *Rhytidium* becomes uncommon in southern Washington, and in Oregon it is known only from Saddle Mountain, near the coast. Capsules are extremely rare, and plants reproduce by fragmentation, severely limiting dispersal to new habitats.

Conservation issues: Hazards are road and trail building, overcollecting at the edge of its range. Occurrence on ridge tops and peaks make it vulnerable to air pollution. Known sites should be rechecked and characterized to help locate additional populations. In

Oregon, other high coastal peaks should be checked, such as Marys Peak and Mt. Hebo, both on the Siuslaw National Forest.

Rhytidium rugosum. -- 1. Plants with capsule, showing secund leaves, giving shoot tips a hooked appearance. -- 2. Leaves, showing wrinkled surface. -- 3. Detail of shoot tip, showing wrinkled and secund leaves. -- 4. Capsules. From Grout (1903), Nyholm (1965), Lawton (1971), Crum and Anderson (1981) and Schofield (1992). Figures from all but Grout (1903) reprinted with permission of the Botanical Society of Lund, Columbia University Press, the Hattori Botanical Laboratory, the Royal British Columbia Museum, and Wilfred B. Schofield.

SCHISTOSTEGA PENNATA (Hedw.) Web. & Mohr
Luminous moss, Goblin gold, Cave moss
Recent synonyms: None.



Status: SAT Appendix 5-H; FEMAT Appendix Table IV-A-3.

Distribution: Circumboreal; in our area known from British Columbia, Alberta, Montana and Washington.

Habitat and ecology: On damp rock, soil and decaying wood, in dark places such as openings of caves or mine shafts, in rock crevices or overhangs (particularly sandstone), in animal burrows, on shaded banks, in crevices of root balls of fallen trees, or around tree roots in dark, dense forests. Also reported from old cellars and under rotting sills in old barns. Light seems to be the limiting factor for *Schistostega*: it can survive where other bryophytes cannot, because of its ability to capture and concentrate low levels of light, just enough to photosynthesize. If the light gets too bright, other bryophytes invade, and *Schistostega* disappears. In many cases, the species is obviously a pioneer on disturbed soil, and despite the abundance of suitable habitat, it remains rare because of its highly irregular distribution.

Description: Plants consisting mostly of persistent protonema, with specialized cells that reflect light entering the darkened recess where the plants grow. From a few feet away, the protonema appears to glow with a pale yellowish-green light, somewhat like the eyeshine of nocturnal animals. When examined out in the open, the protonema is actually quite inconspicuous, unlike that of *Buxbaumia*. From the protonema arise scant to dense clusters of delicate, pale bluish green, erect leafy shoots (2)4-7(10) mm tall. Sterile shoots have leaves 0.5-1.2 mm long, ecostate, in two rows on opposite sides of the stem, like a fern frond, with leaf bases decurrent and merging with adjacent leaves, loosely curled under when dry; leaf margins entire, with marginal cells slightly thinner and longer, forming an indistinct border; inner leaf cells smooth, thin-walled, giving the plants a pale and delicate texture. Fertile shoots with clusters of tiny lanceolate leaves at the tips. Setae 1.5(2)-4 (5) mm long. Capsules erect, globose, 0.4-0.5 mm long, lacking a peristome.

Distinctive characters: (1) Greenish-gold reflection from "glow-in-the-dark" protonema, (2) growing in dark places, with (3) tiny fern-like leafy shoots.

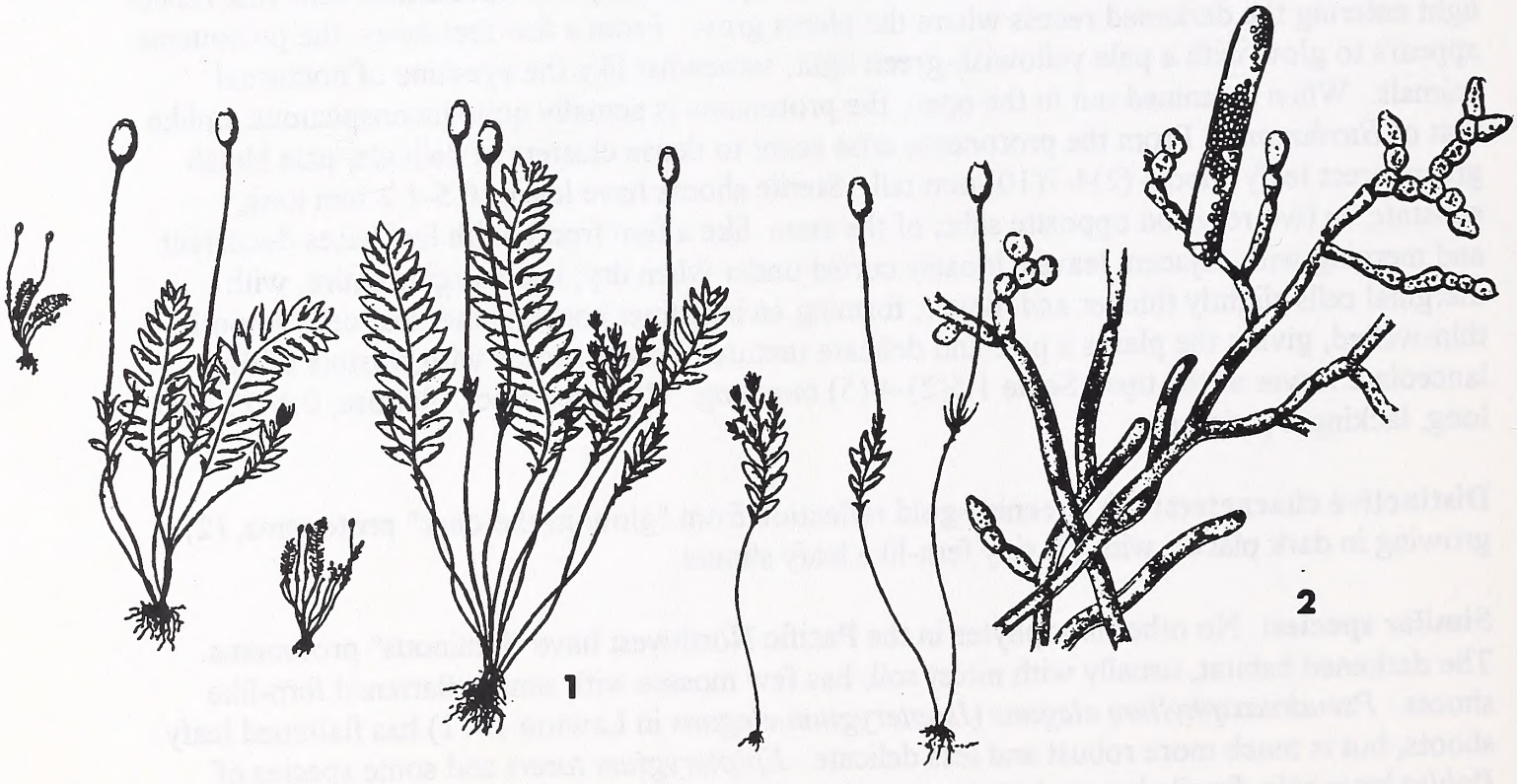
Similar species: No other bryophytes in the Pacific Northwest have "luminous" protonema. The darkened habitat, usually with moist soil, has few mosses with similar flattened fern-like shoots. *Pseudotaxiphyllum elegans* (*Isopterygium elegans* in Lawton 1971) has flattened leafy shoots, but is much more robust and less delicate. *Epipterygium tozeri* and some species of *Pohlia* have pale, fragile leaves, but they are all larger than *Schistostega*, with broad, costate and lanceolate leaves. *Fissidens bryoides* is very small and has two opposite rows of flattened leaves, overlapping for some of their length, but it lacks the delicate, transparent look of

Schistostega, and its leaves are costate and bordered.

Other descriptions and illustrations: Grout 1903: 186, *187*; Grout 1935: 103; Nyholm 1960: 352, *353*; Watson 1968: 242; Lawton 1971: 161, *Pl. 88*; Smith 1978: 358; Crum and Anderson 1981: 116, *117*; Ireland 1982: 112, *113*; Crum 1983: 154, *156*; Noguchi 1988: *420*, 421; Schofield 1992: 270, *271*; Pojar and Mackinnon 1994: 462.

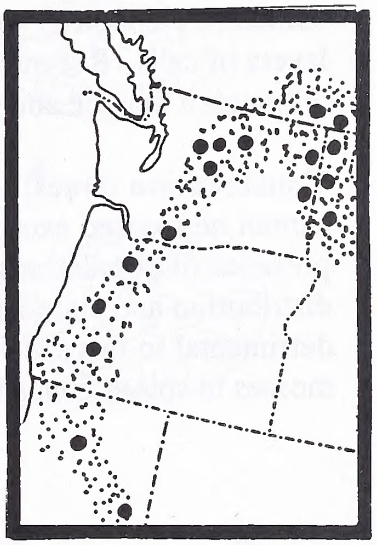
Notes and comments: *Schistostega* is rare throughout its range, but may be abundant where it occurs. In our area, it has not been found south of Washington. It is one of the most bizarre and famous mosses, highly sought after by collectors because it is so odd, and once seen, so unforgettable. Reams of prose have been written about *Schistostega*, and it has figured in legends about greedy people who snatch up what they think are glittering gold and jewels, only to find plain old soil in the cruel light of day (see Crum 1983). Drops of dew or rain on other mosses or fern gametophytes sometimes produce a greenish-yellow reflection that can fool you into thinking you have *Schistostega*. The "luminous" effect can only be seen from a certain angle, a little to the side of the opening of the recess in which the plants grow. Crowding too close to the opening may block out the light, and the reflection will disappear.

Conservation Issues: *Schistostega* is obviously dependent on dark, damp habitats. Known sites should be revisited, and likely new sites seen in the field should be checked for the tell-tale glow. Logging, construction of roads and trails, or other activities that increase incident light and decrease humidity, may cause the species to disappear.



Schistostega pennata -- 1. Plants, showing sterile and fertile shoots. -- 2. Protonema, with circular grapelike cells containing reflective lenses. From Grout (1903).

SCOULERIA MARGINATA Britt.
Margined black knotmoss, Doughnut capsule moss
Recent synonyms: None



Status: FEMAT Appendix Table IV-A-3; FSEIS Appendix J2; ROD Table C-3.

Distribution: Endemic to Pacific Northwest. Southwestern British Columbia, Washington, Idaho, Oregon, northern California.

Habitat and ecology: Forming dense, often extensive black mats on rocks in the spray zone of streams and waterfalls, often submerged at least part of year. Exposed to shaded. It is an efficient sediment trapper in swift streams. Associated species include *Scouleria aquatica*, *Racomitrium aciculare*, *Schistidium rivulare* and *Scleropodium obtusifolium*.

Description: Plants robust, decumbent to pendant, 2-10 cm long, irregularly branched. Leafy shoots to 5 mm wide. Leaves to 4 mm long and 1.5 mm wide, green at shoot tips, brown or black below, appressed and flexuose to contorted and widely spreading when dry. Costa prominent at back of leaf. Leaf margins with a thickened, brown or blackish band of 3-5 layers of cells, best developed at the broadest part of the leaf. Capsules dark brown or black, at ends of branches, resembling doughnuts or cheerios lying on their sides. When the capsule dries, its lid is held aloft by a stalk, like an umbrella, protruding through the hole of the doughnut. Peristome absent.

Distinctive characters: (1) Robust blackish moss on wet rocks in or close to moving water, (2) with uniquely-shaped capsules looking like doughnuts lying on their sides, will get you to the genus *Scouleria*. *S. marginata* is distinguished by (1) its multistratose leaf border and (2) lack of a peristome.

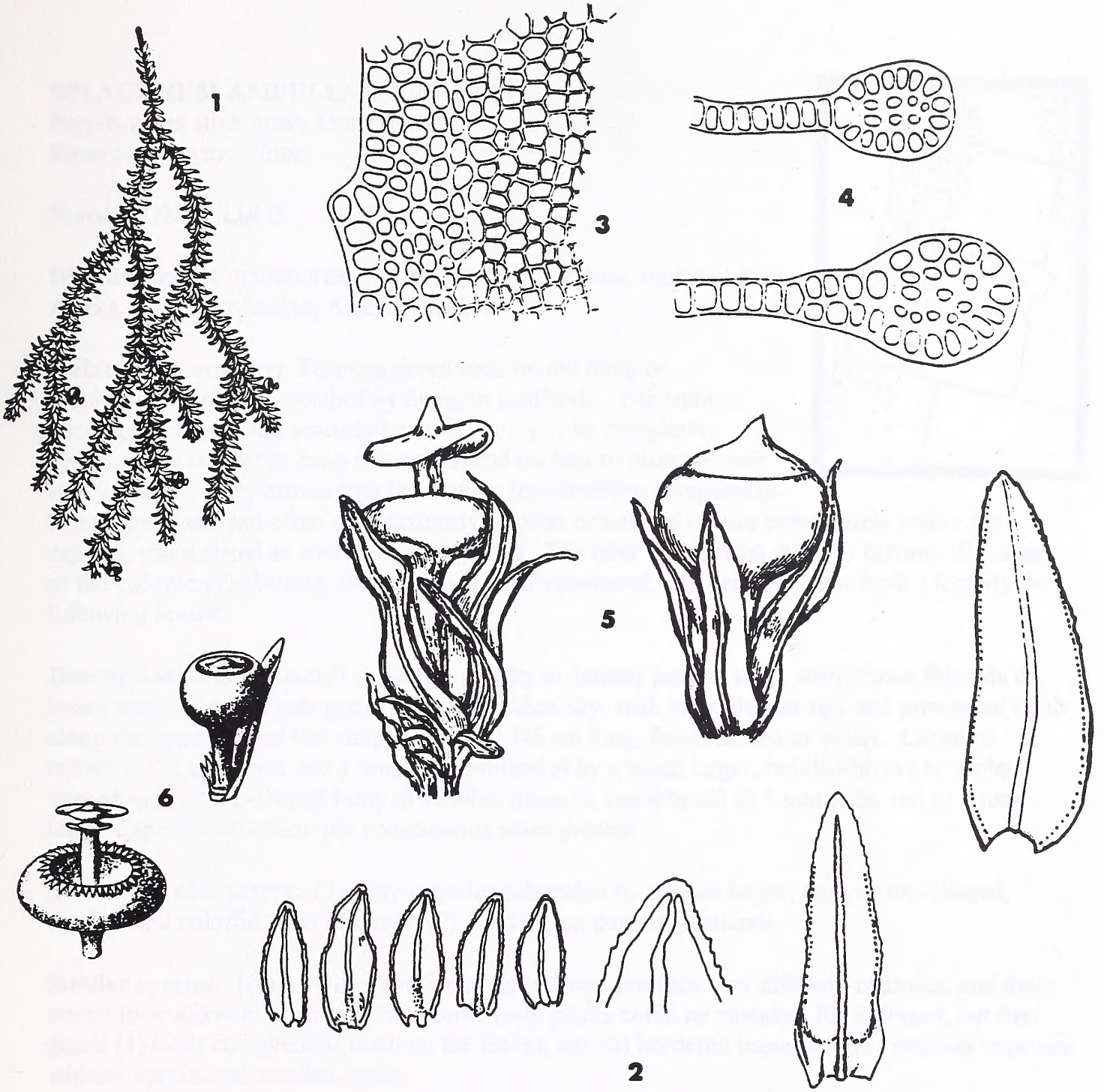
Similar species: The widespread and common *Scouleria aquatica* is nearly identical in appearance and habitat, and both species are known to grow in mixed stands. Its (1) leaf margins are unistratose or sometimes bistratose and (2) capsules have a peristome. *Schistidium rivulare* may occur in the same habitat and is also blackish, but (1) is usually only 1-4 cm long, with (2) leaves imbricate and hardly flexed when dry, with recurved margins, and (3) cup-shaped capsules with a peristome, partially hidden among the leaves.

Other descriptions and illustrations: Jones 1933: 43, *Pl. 18*; Lawton 1971: 149, *Pl. 79*; Churchill 1985: 65.

Notes and comments: *Scouleria aquatica* can also have black or brown leaf margins that could be mistaken for the thickened borders of *S. marginata*. Using a razor blade, it is best to cut cross-sections from the widest part of the leaves, and check the borders under a compound microscope. *Although S. aquatica* may have a dark leaf border, it is usually unistratose, but

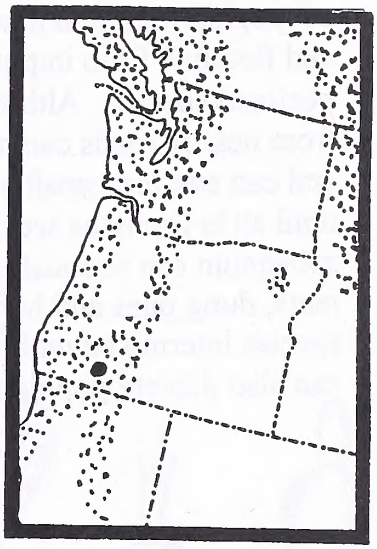
sometimes its border can be bistratose. The border of *S. marginata* always has three or more layers of cells. Recent review of herbarium specimens indicates that this species is uncommon, although it may be abundant locally.

Conservation issues: Lower-elevation streams are usually privately owned, and protection cannot be assured except on federal lands. Known sites should be searched to reconfirm presence of populations, and efforts made to find new populations on federal land, to assess distribution and abundance. Upstream activities that cause excessive siltation could be detrimental to this species. Recreational gold dredging and recreational boating can also damage mosses in splash zones by abrasion or removal of moss mats for gold recovery.



Scouleria marginata. -- 1. Plant with capsules. -- 2. Leaves, showing thickened costa and margins. -- 3. Cells of leaf margin, showing thick-walled cells at margin. -- 4. Cross-section of leaf margins, showing multistratose layer of cells at margin. -- 5. Capsules, wet and dry, showing exserted operculum on dry, shrunken capsule. -- 6. Schematic drawing of wet and dry capsules, showing their differences. From Brotherus (1909), Jones (1933), Lawton (1971) and Churchill (1985). Figures from Lawton (1971) and Churchill (1985) reprinted with permission of the Hattori Botanical Laboratory, and the Nordic and Dutch Bryological Society.

SPLACHNUM AMPULLACEUM Hedw.
Purple-vased stink moss, Dung moss
Recent synonyms: None



Status: ONHP List 2.

Distribution: Circumboreal. In the Pacific Northwest, reported from Alaska, British Columbia, Alberta, Oregon.

Habitat and ecology: Forming green sods on old dung of herbivores, or on soil enriched by dung, in peatlands. The sodden, decomposed dung will scarcely be visible, or may be completely absent. This and other dung mosses depend on flies to disperse their sticky spores. They attract flies by exuding foul-smelling compounds from specialized and often conspicuously swollen or colored tissues immediately below the capsule, using visual as well as olfactory cues. The odor varies from dung to carrion. Because of the ephemeral substrate, this species is itself ephemeral, and can disappear from a locality the following season.

Description: Plants erect, 1-3 cm tall, usually in densely packed sods, with brown rhizoids on lower stems. Leaves pale green, contorted when dry, with long, slender tips and prominent teeth along the upper half of the margin. Setae 0.3-6 cm long, flexuose, red or violet. Capsules cylindric, 0.1 mm wide and 1 mm long, subtended by a much larger, reddish-brown to violet, vase-shaped or top-shaped body of swollen tissue (a hypophysis) to 3 mm wide and to 6 mm long. Capsules abundant and conspicuous when present.

Distinctive characters: (1) Tiny capsules subtended by a much larger, vase or top-shaped, swollen and colorful mass of tissue, (2) growing on dung in peatlands.

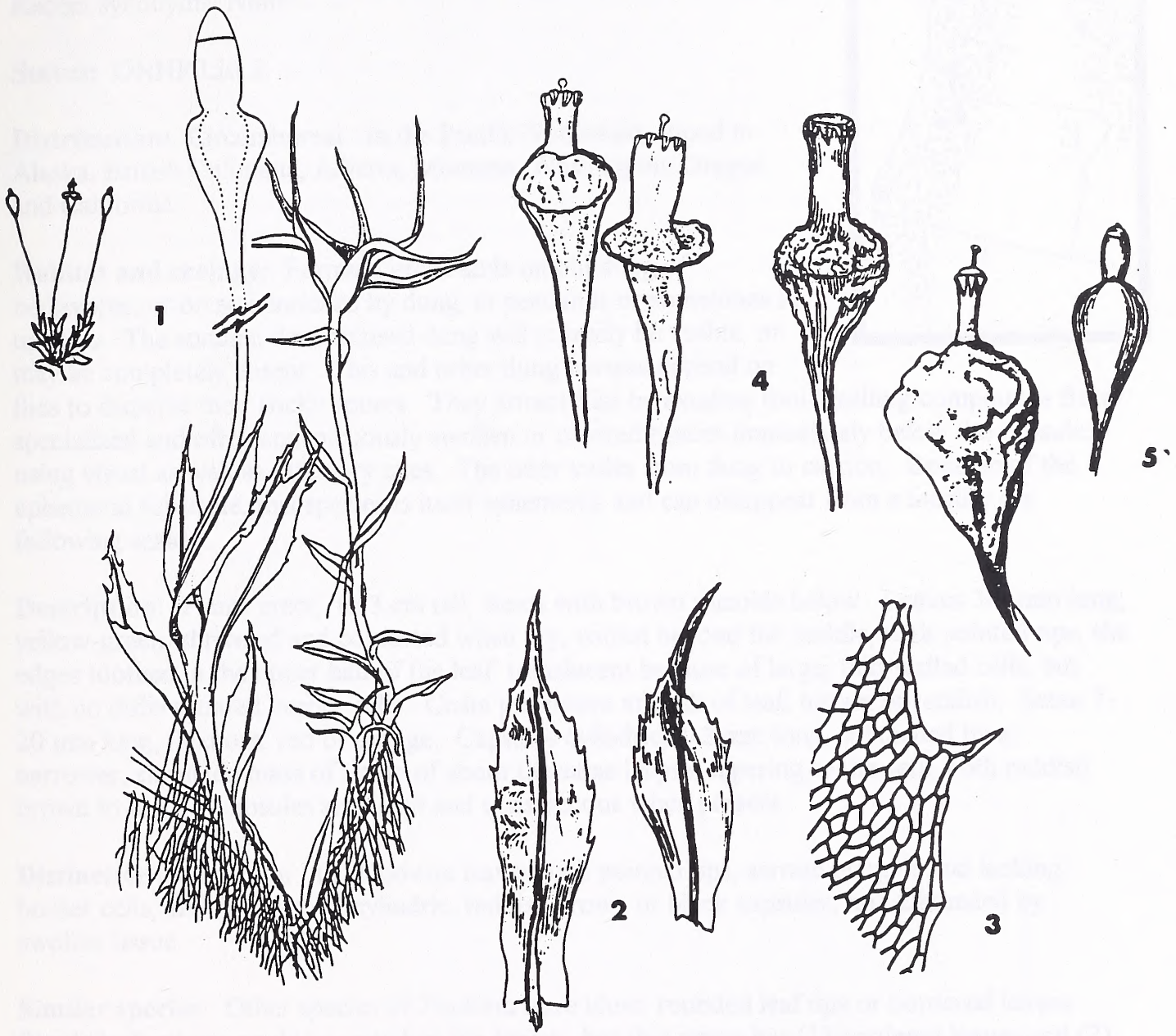
Similar species: None. Other species of *Splachnum* produce very different capsules, and there are no look-alikes in other genera. Sterile leafy plants could be mistaken for a *Bryum*, but that genus (1) lacks conspicuous teeth on the leaves, has (2) bordered leaves and (3) pendant capsules without specialized swollen tissue.

Other descriptions and illustrations: Grout 1903: 188; Sayre 1935: 101; Nyholm 1956: 187; Lawton 1971: 157, *Pl. 85*; Crum and Anderson 1981: 496, *498*; Noguchi 1988: 419.

Notes and comments: One of the more striking of the bizarre dung mosses, *S. ampullaceum* is cited as rare by most sources.

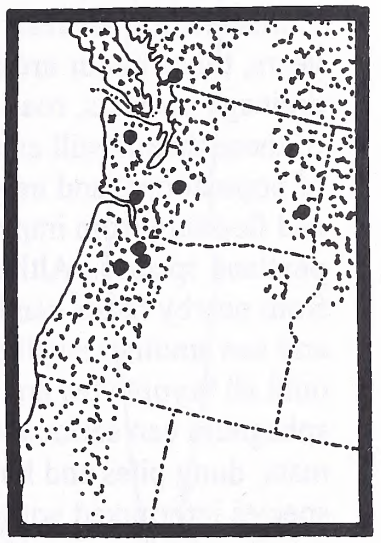
Conservation issues: Peatlands are fragile ecosystems that need protection. Over the last 100 years, those in our area have been impacted by grazing, water diversion and impoundment, drainage projects, road construction, and commercial harvest of peat and sphagnum moss. Most of these threats still exist today. All known localities should be searched to reconfirm presence

of populations, and new populations need to be found. Dewatering from drainage or diversion, and flooding from impoundment cause replacement of plant communities and disappearance of peatland species. Although federal regulations prohibit building new roads in wetlands, dust from nearby roads can have a significant impact on the nutrient status of wetlands, can alter pH, and can smother small plants such as bryophytes. Livestock may trample and churn peatland until all bryophytes are destroyed, especially around water holes. Commercial collecting of sphagnum can seriously deplete bryophyte diversity in mires, especially on hummocks. Moss mats, dung piles and hummocks are destroyed during collection, and tiny hummock-dwelling species intermixed with sphagnum moss may take many years to recover. Scientific collecting can also deplete populations of rare mosses such as *Splachnum*.



Splachnum ampullaceum. -- 1. Plants with capsules, those on left about natural size; the seta on the plant on right has been shortened to condense the drawing. -- 2. Leaves. -- 3. Cells at margin of leaf. -- 4. Mature capsules, showing small cylindrical urn and swollen hypophysis beneath it. -- 5. Immature capsule. From Grout (1903), Noguchi (1988) and Crum and Anderson (1981). Figures from all but Grout (1903) reprinted with permission of Columbia University Press, and the Hattori Botanical Laboratory.

TAYLORIA SERRATA (Hedw.) Bruch & Schimp. *in* B.S.G.
Broad-leaved stink moss, Dung moss
Recent synonyms: None



Status: ONHP List 2.

Distribution: Circumboreal. In the Pacific Northwest, found in Alaska, British Columbia, Alberta, Montana, Washington, Oregon and California.

Habitat and ecology: Forming green sods on old dung of herbivores, or on soil enriched by dung, in peatlands or sometimes in uplands. The sodden, decomposed dung will scarcely be visible, or may be completely absent. This and other dung mosses depend on flies to disperse their sticky spores. They attract flies by exuding foul-smelling compounds from specialized and often conspicuously swollen or colored tissues immediately below the capsule, using visual as well as olfactory cues. The odor varies from dung to carrion. Because of the ephemeral substrate, this species is itself ephemeral, and can disappear from a locality the following season.

Description: Plants erect, to 3 cm tall, stems with brown rhizoids below. Leaves 3-4 mm long, yellow-green, shriveled and contorted when dry, widest beyond the middle, with pointed tips, the edges toothed in the upper half of the leaf, translucent because of large, thin-walled cells, but with no differentiated border cells. Costa prominent at back of leaf, brown or reddish. Setae 7-20 mm long, flexuose, red or orange. Capsules cylindric, 1-2 mm long, subtended by a narrower, shrunken mass of tissue of about the same length, tapering to the seta, both reddish brown to black. Capsules abundant and conspicuous when present.

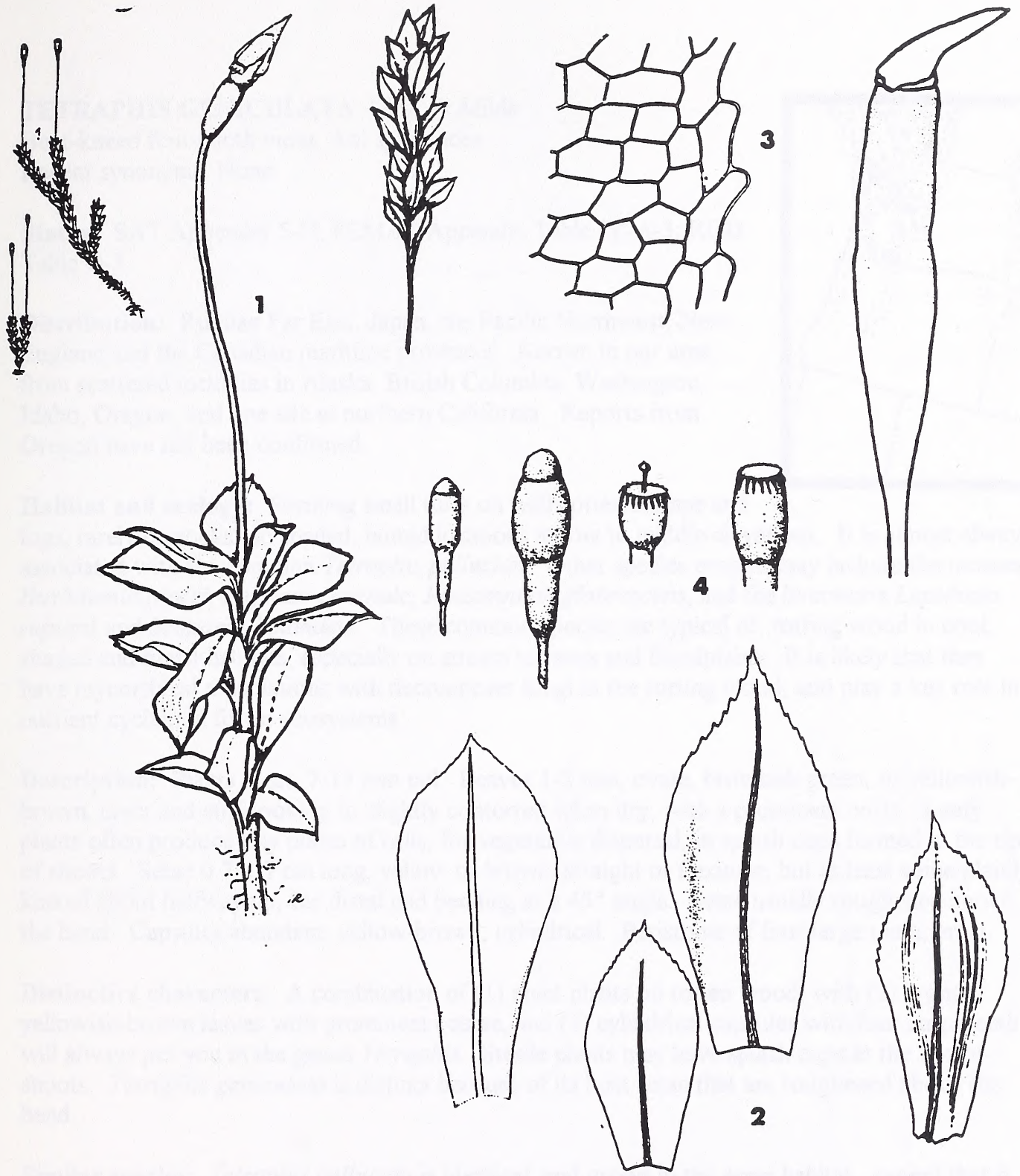
Distinctive characters: (1) Obovate leaves with pointed tips, serrate margins and lacking border cells, and (2) narrow, cylindric, reddish brown or black capsules, not subtended by swollen tissue.

Similar species: Other species of *Tayloria* have blunt, rounded leaf tips or bordered leaves. Sterile leafy plants could be mistaken for *Bryum*, but that genus has (1) bordered leaves and (2) pendant capsules with no specialized tissue below the capsule. *Tetraplodon mnioides* has (1) no teeth on the leaves, (2) and its capsules are usually subtended by a slightly more swollen mass of tissue.

Other descriptions and illustrations: Sayre 1935: 95, *Pl. 41*; Nyholm 1956: 180; Lawton 1971: 160, *Pl. 87*; Crum and Anderson 1981: 486.

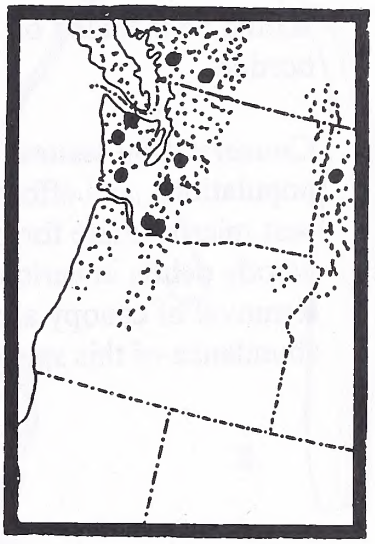
Notes and comments: Many of our records are early collections, made around the turn of the century. Possibly, it was more common because of the greater amount of horse and cow manure along roads and trails, in the days before the automobile.

Conservation issues: Peatlands are fragile ecosystems that need protection. Over the last 100 years, those in our area have been impacted by grazing, water diversion and impoundment, drainage projects, road construction, and commercial harvest of peat and sphagnum moss. Most of these threats still exist today. All known localities should be searched to reconfirm presence of populations, and new populations need to be found. Dewatering from drainage or diversion, and flooding from impoundment cause replacement of plant communities and disappearance of peatland species. Although federal regulations prohibit building new roads in wetlands, dust from nearby roads can have a significant impact on the nutrient status of wetlands, can alter pH, and can smother small plants such as bryophytes. Livestock may trample and churn peatland until all bryophytes are destroyed, especially around water holes. Commercial collecting of sphagnum can seriously deplete bryophyte diversity in mires, especially on hummocks. Moss mats, dung piles and hummocks are destroyed during collection, and tiny hummock-dwelling species intermixed with sphagnum moss may take many years to recover. Scientific collecting can also deplete populations of rare mosses such as *Tayloria*.



Tayloria serrata. -- 1. Plants with capsules, those in upper left about natural size. -- 2. Leaves. -- 3. Cells at margin of leaf. -- 4. Capsules, with and without calyptra and operculum, showing exserted columella on one. From Sayre (1935), Lawton (1971) and Crum and Anderson (1981). Figures from all but Sayre (1935) reprinted with permission of Columbia University Press, and the Hattori Botanical Laboratory.

TETRAPHIS GENICULATA Girg. *ex* Milde
Bent-kneed four-tooth moss, Ant spearmoss
Recent synonyms: None



Status: SAT Appendix 5-H; FEMAT Appendix Table IV-A-3; ROD Table C-3.

Distribution: Russian Far East, Japan, the Pacific Northwest, New England and the Canadian maritime provinces. Known in our area from scattered localities in Alaska, British Columbia, Washington, Idaho, Oregon, and one site in northern California. Reports from Oregon have not been confirmed.

Habitat and ecology: Forming small turfs on well-rotted stumps and logs, rarely on rocks, in shaded, humid locations at low to middle elevations. It is almost always associated with the common *Tetraphis pellucida.* Other species present may include the mosses *Buxbaumia piperi, Hypnum circinale, Rhizomnium glabrescens*, and the liverworts *Lepidozia reptans* and *Scapania bolanderi*. These common species are typical of rotting wood in cool, shaded and moist habitats, especially on stream terraces and floodplains. It is likely that they have mycorrhizal associations with decomposer fungi in the rotting wood, and play a key role in nutrient cycling in forest ecosystems.

Description: Plants erect, 7-15 mm tall. Leaves 1-2 mm, ovate, brownish green, or yellowish-brown, erect and stiff-looking to slightly contorted when dry, with a prominent costa. Leafy plants often produce tiny plates of cells, for vegetative dispersal, in splash cups formed at the tips of shoots. Setae 0.7-1.7 cm long, yellow or brown, straight or flexuose, but at least some plainly kinked about halfway up, the distal end bending at a 45° angle. Setae usually roughened above the bend. Capsules abundant, yellow-brown, cylindrical. Peristome of four large teeth, erect.

Distinctive characters: A combination of (1) erect plants on rotten wood, with (2) broad yellowish-brown leaves with prominent costae, and (3) cylindrical capsules with four large teeth will always put you in the genus *Tetraphis.* Sterile plants may have splash cups at the tips of shoots. *Tetraphis geniculata* is distinct because of its bent setae that are roughened above the bend.

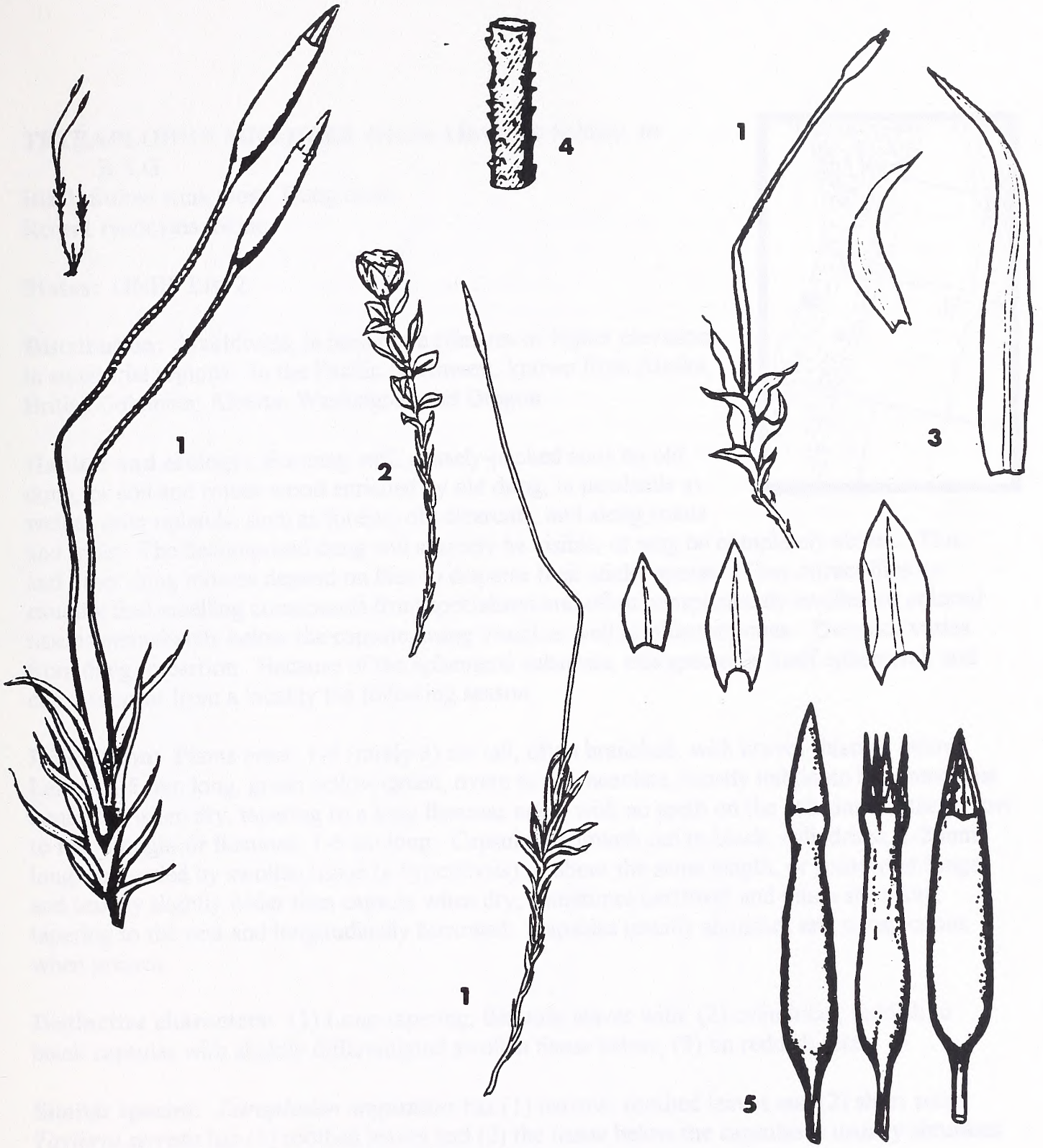
Similar species: *Tetraphis pellucida* is identical, and grows in the same habitat, except that it has consistently straight or flexuose, smooth setae.

Other descriptions and illustrations: Grout 1936: 6, *Pl. 2*; Lawton 1971: 27, *Pl. 2*; Crum and Anderson 1981: 1243, *1244.*.

Notes and comments: *T. geniculata* often grows in mixed stands with *T. pellucida*, and sterile leafy shoots of the two species are identical. The splash cups are for vegetative dispersal during the rainy season, and capsules are more prominent during the dry season. This taxon probably

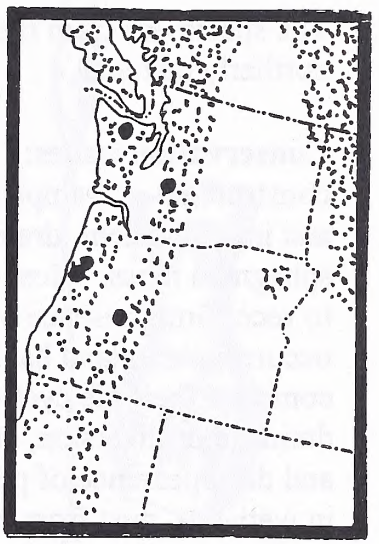
should be included on state lists of rare plants, as it seems to be rare south of the Canadian border.

Conservation issues: Known localities should be searched to reconfirm presence of populations, and efforts made to locate new populations. A closed, dense canopy provides the best microclimate for optimal development of species favoring decaying wood. Input of large woody debris in various decay classes and diameters is also necessary for long-term viability. Removal of canopy and subsequent insolation and drying of the understory would reduce the abundance of this species and the other more common taxa associated with rotting wood.



Tetraphis geniculata. -- 1. Plants with capsules, those at upper left about natural size. -- 2. Plant with splash cup, containing asexual propagules, at tip of shoot. -- 3. Leaves. -- 4. Detail of seta, with roughened surface. -- 5. Capsules, with and without operculum, showing four peristome teeth wet and dry. From Grout (1936), Lawton (1971), Flowers (1973), and Crum and Anderson (1981). Figures from all but Grout (1936) reprinted with permission of Brigham Young University Press, Columbia University Press, and the Hattori Botanical Laboratory.

TETRAPLODON MNIOIDES (Hedw.) Bruch & Schimp. *in* B.S.G.
Black-fruited stink moss, Dung moss
Recent synonyms: None



Status: ONHP List 2.

Distribution: Worldwide, in temperate climates or higher elevations in equatorial regions. In the Pacific Northwest, known from Alaska, British Columbia, Alberta, Washington and Oregon.

Habitat and ecology: Forming stiff, densely-packed sods on old dung, or soil and rotten wood enriched by old dung, in peatlands as well as drier uplands, such as forests, old clearcuts, and along roads and trails. The decomposed dung will scarcely be visible, or may be completely absent. This and other dung mosses depend on flies to disperse their sticky spores. They attract flies by exuding foul-smelling compounds from specialized and often conspicuously swollen or colored tissues immediately below the capsule, using visual as well as olfactory cues. The odor varies from dung to carrion. Because of the ephemeral substrate, this species is itself ephemeral, and can disappear from a locality the following season.

Description: Plants erect, 1-4 (rarely 8) cm tall, often branched, with brown rhizoids below. Leaves 2-5 mm long, green yellow-green, ovate to oblanceolate, mostly imbricate but somewhat contorted when dry, tapering to a long flexuose apex, with no teeth on the margins. Setae yellow to red, straight or flexuose, 1-6 cm long. Capsules yellowish red to black, cylindrical, 1-2 mm long, subtended by swollen tissue (a hypophysis) of about the same length, or somewhat longer and usually slightly wider than capsule when dry, sometimes narrower and much shrunken, tapering to the seta and longitudinally furrowed. Capsules usually abundant and conspicuous when present.

Distinctive characters: (1) Long-tapering, flexuose leaves with (2) cylindrical, reddish to black capsules with slightly differentiated swollen tissue below, (3) on reddish setae.

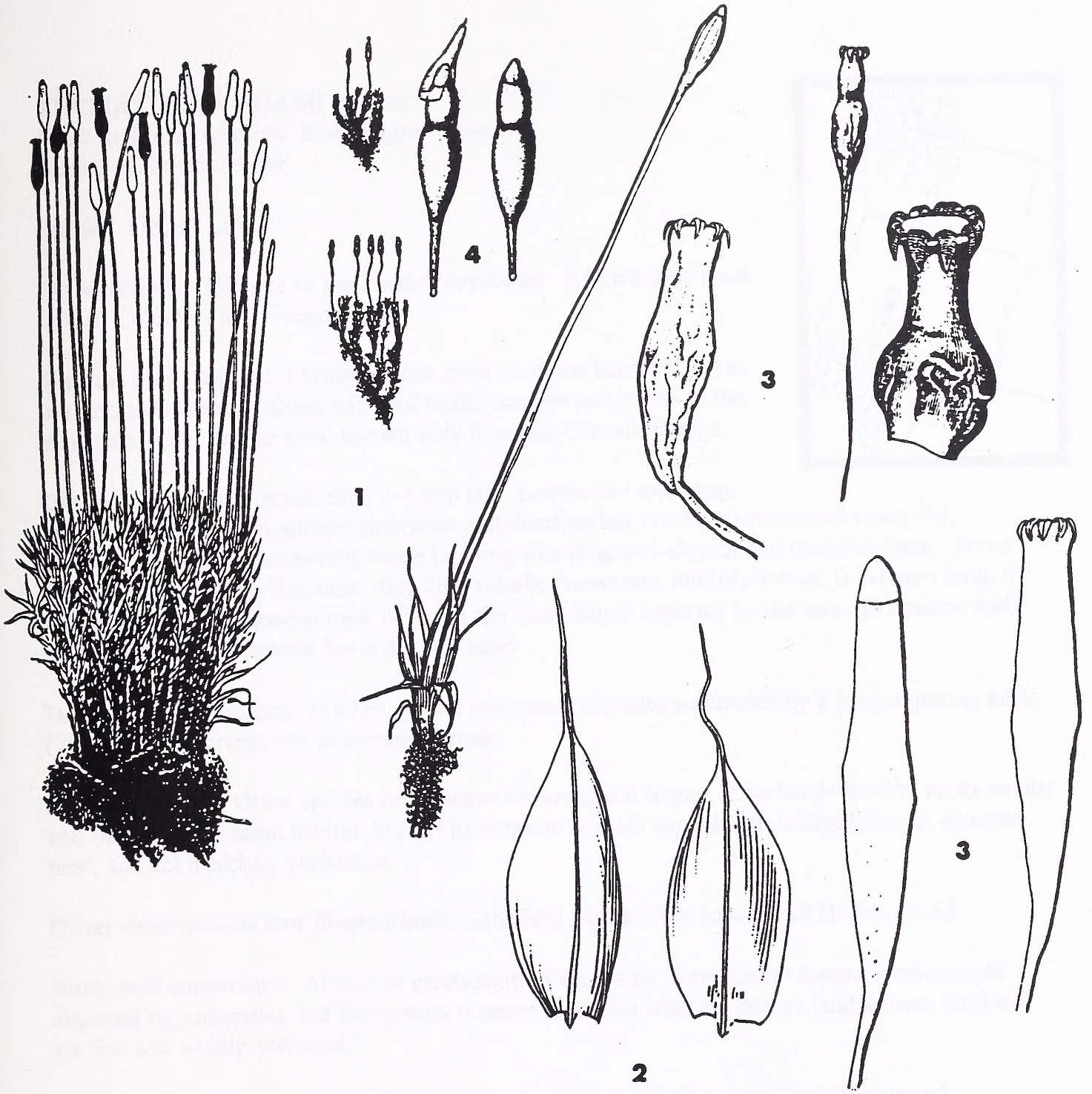
Similar species: *Tetraplodon angustatus* has (1) narrow, toothed leaves and (2) short setae. *Tayloria serrata* has (1) toothed leaves and (2) the tissue below the capsules is usually shrunken and narrower than the capsules.

Other descriptions and illustrations: Grout 1903: 189; Sayre 1935: 98; Nyholm 1956: 184; Lawton 1971: 161, *Pl. 88*; Crum and Anderson 1981: *490*, 491; Noguchi 1988: 417; Schofield 1992: 286, *287*.

Notes and comments: This species grows in drier forests as well as in peatlands, and seems to have a broader ecological tolerance than other dung mosses. It is also more widely distributed, but still apparently rare south of the Canadian border, as there are few documented collections.

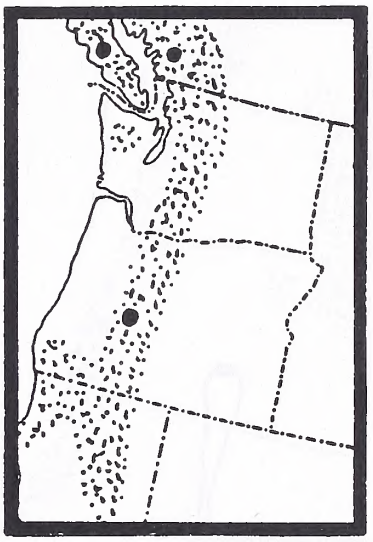
The specimens from the southern part of the range tend to be diminutive when compared to more northerly material.

Conservation issues: Those populations along trails and roads could be wiped out by construction or trampling. Those in peatlands have been impacted by grazing, water diversion and impoundment, drainage projects, road construction, and commercial harvest of peat and sphagnum moss. Most of these threats still exist today. All known localities should be searched to reconfirm presence of populations, and efforts made to locate new populations. Populations occurring in upland habitats need protection for a year or two, with monitoring, to allow them to complete their life cycles and disperse spores to new habitats. In wetlands, dewatering from drainage or diversion, and flooding from impoundment cause replacement of plant communities and disappearance of peatland species. Although federal regulations prohibit building new roads in wetlands, dust from nearby roads can have a significant impact on the nutrient status of wetlands, can alter pH, and can smother small plants such as bryophytes. Livestock may trample and churn peatland until all bryophytes are destroyed, especially around water holes. Commercial collecting of peat and sphagnum can seriously deplete bryophyte diversity in mires, especially on hummocks. Moss mats, dung piles and hummocks are destroyed during collection, and tiny hummock-dwelling species intermixed with sphagnum moss may take many years to recover.



Tetraplodon mnioides. -- 1. Plants with capsules, the small ones about natural size; the dense sod on left is typical of what one sees in the field. -- 2. Leaves. -- 3. Mature capsules, with and without operculum, wet and dry. -- 4. Immature capsules, with and without calyptra. From Grout (1903), Lawton (1971), Crum and Anderson (1981), Noguchi (1988), and Schofield (1992). Figures from all but Grout (1903) reprinted with permission of Columbia University Press, the Hattori Botanical Laboratory, the Royal British Columbia Museum, and Wilfred B. Schofield.

TREMATODON BOASII Schof.
Boas' long-necked moss, Boas' pygmy moss
Recent synonyms: None



Status: ONHP List 3.

Distribution: Endemic to the Pacific Northwest. Known only from British Columbia and Oregon.

Habitat and ecology: Forming loose mats on moist bare soil, often with organic content, along edges of trails, streams and ponds in the subalpine zone. In our area, known only from the Cascade Range.

Description: Plants erect, tiny, 2-4 mm tall. Leaves 2-4 mm long, green or yellow-green, glossy, imbricate and flexuose but not much contorted when dry, consisting of a short, sheathing blade tapering to a long awl-shaped and flexuose apex. Setae yellow, 1-4 mm long, flexuose. Capsules usually numerous, reddish-brown, 0.5-1 mm long, 0.5 mm wide, with a yellowish neck of about the same length tapering to the seta. Peristome well developed. Lid of capsule has a distinct beak.

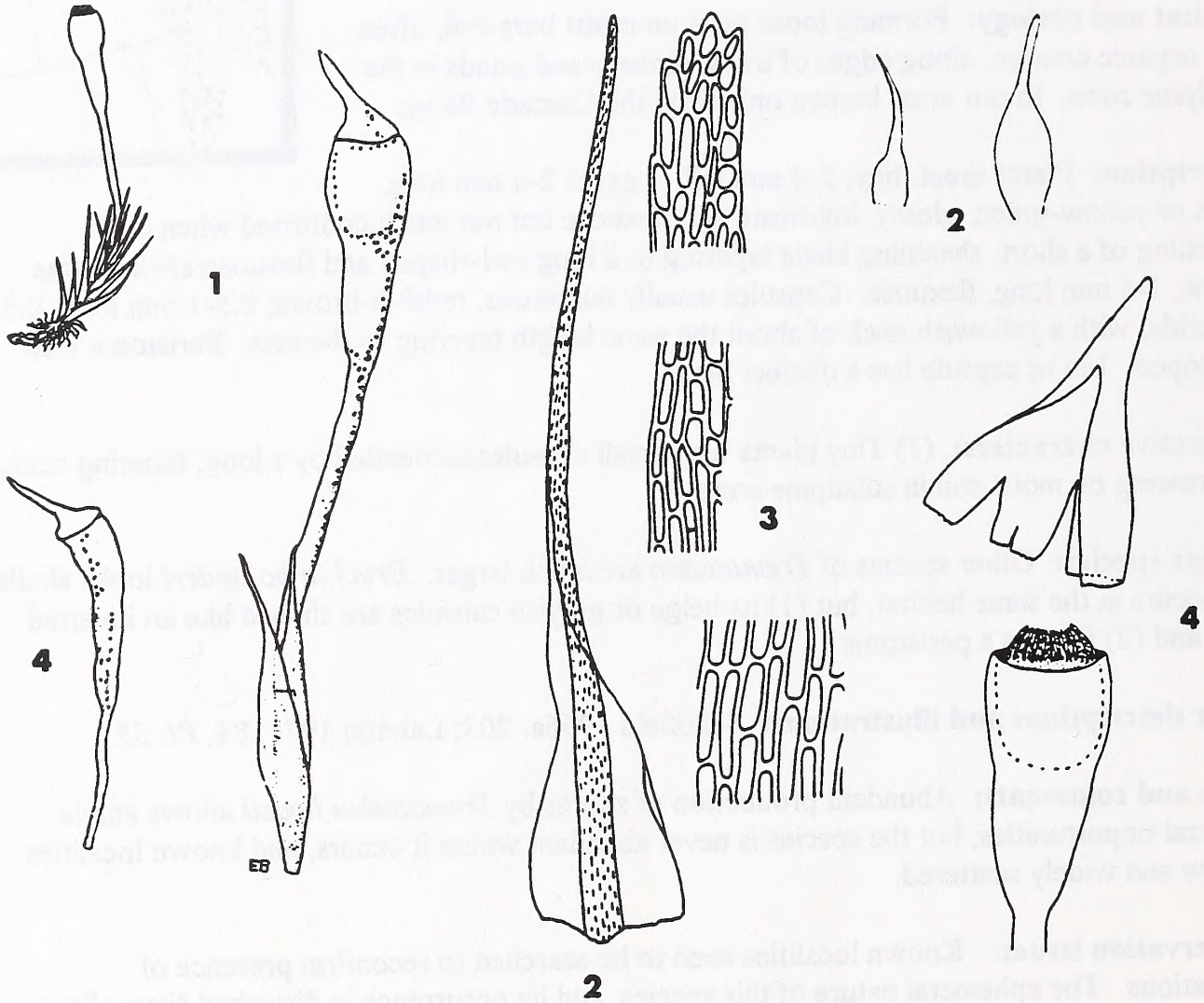
Distinctive characters: (1) Tiny plants with small capsules subtended by a long, tapering neck, (2) growing on moist soil in subalpine areas.

Similar species: Other species of *Trematodon* are much larger. *Bruchia bolanderi* looks similar and occurs in the same habitat, but (1) its beige or grayish capsules are shaped like an inverted pear, and (2) it lacks a peristome.

Other descriptions and illustrations: Schofield 1966a: 203; Lawton 1971: 84, *Pl. 35*.

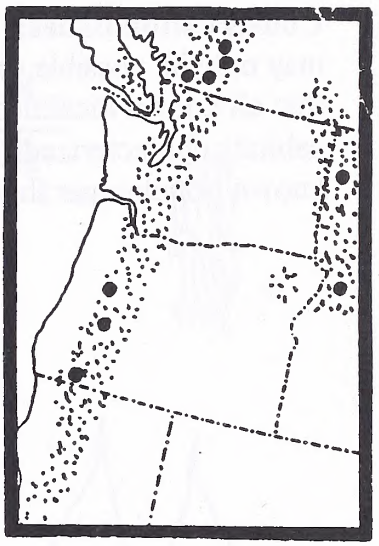
Notes and comments: Abundant production of spores by *Trematodon boasii* allows ample dispersal opportunities, but the species is never abundant where it occurs, and known localities are few and widely scattered.

Conservation issues: Known localities need to be searched to reconfirm presence of populations. The ephemeral nature of this species, and its occurrence in disturbed sites, allows some flexibility in management. Routing of trails away from known sites would probably be adequate to protect populations.



Trematodon boasii. -- 1. Plants with capsules. -- 2. Leaves. -- 3. Cells at tip, middle and base of leaves. -- 4. Capsules with and without calyptra and operculum. From Schofield (1966a) and Lawton (1971). Figures reprinted with permission of the American Bryological and Lichenological Society, and the Hattori Botanical Laboratory.

TRIPTEROCLADIUM LEUCOCLADULUM (C. Müll.) Jaeg.
Silky-thread moss
Recent synonyms: None



Status: ONHP List 1.

Distribution: Endemic to the Pacific Northwest. British Columbia, Washington, Idaho, Oregon, California.

Habitat and ecology: Forming dense silky mats on shaded to exposed rocks, cliffs and bark of hardwoods such as Garry oak, tan oak, canyon live oak and bigleaf maple, occurring mostly at low elevations. Associated species may include *Antitrichia californica, Claopodium, Dendroalsia abietina, Homalothecium nuttallii, Isothecium myosuroides, Neckera, Porella navicularis* and *Plagiomnium venustum.*

Description: Plants tufted to pendant, 1-5 cm long, irregularly branched, the branches more slender than the stems, becoming slender and threadlike, round in cross section, 0.5 mm wide, with the tips filiform. Leaves ovate-lanceolate, 1-1.2 mm long, 0.5 mm wide, green or yellow-green, closely imbricate when dry, the margins recurved near the base. Upper leaf cells linear, without papillae, the alar cells small and squarish, in distinct groups. Branch leaves faintly and irregularly toothed. Costa short and double, or altogether absent. Capsules rare, 1.5 mm long, brown, asymmetrical, curved, erect or inclined. Peristome well developed.

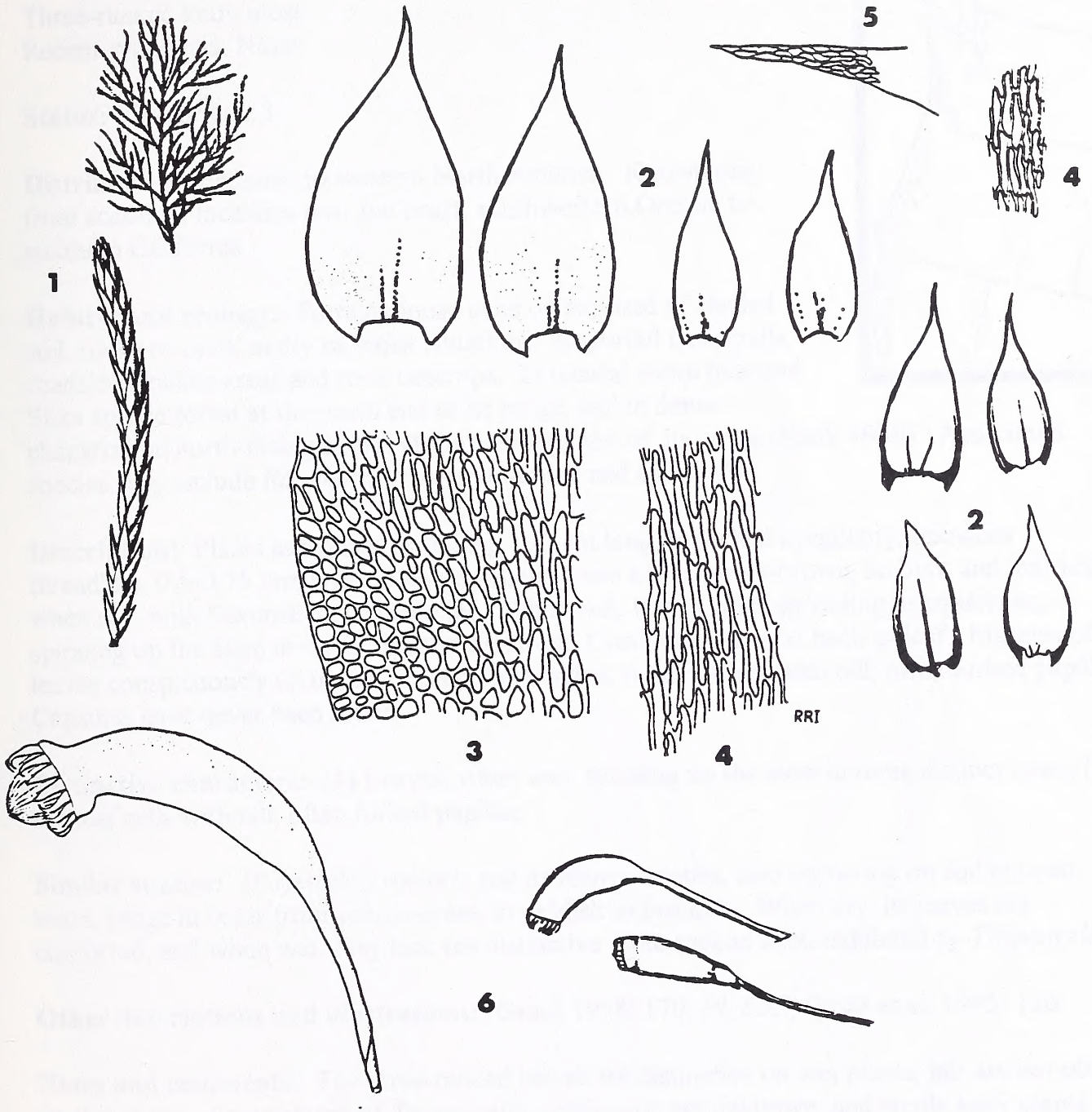
Distinctive characters: (1) Slender, silky shoots on rock or bark, with leaves (2) ovate-lanceolate and (3) with the costa short and double, or none at all.

Similar species: *Isothecium myosuroides* has tufted as well as long-filiform growth habits, and grows in the same habitats. It differs from *Tripterocladium* in (1) its larger size and (2) leaves with a single costa and toothed leaves. *Homalothecium nuttallii* often grows intermixed with *Tripterocladium* on the bark of hardwoods. Although it usually has an adnate, creeping habit on bark, with short, pinnate and yellow-glossy branches tightly upcurled when dry, it sometimes forms glossy, trailing branches not unlike *Tripterocladium*. It differs in having its leaves (1) narrowly attenuate, (2) with a strong, single costa, (3) longitudinally wrinkled, and (4) the branch leaves toothed to the base, especially in the alar region.

Other descriptions and illustrations: Leiberg 1892; Brotherus 1909: 890; Grout 1932: 151, *Pl. 42I*; Lawton 1971: 328, *Pl. 193.*

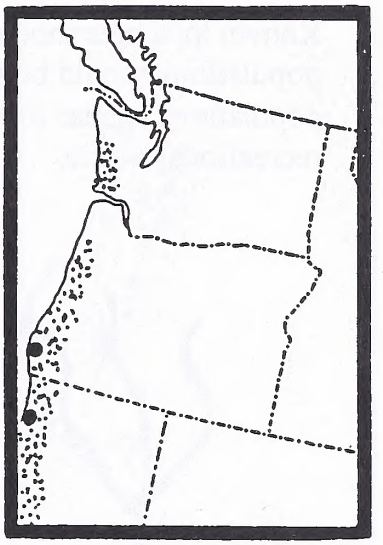
Notes and comments: Like *Isothecium*, this species is polymorphic, with forms ranging from larger, tufted plants to masses of very sender, long, filiform branches with leaves showing long-attenuate, flexuose tips. This is the only species in the genus, originally described from oaks near Roseburg, Oregon. It is widely scattered in the Pacific Northwest, but a paucity of herbarium collections suggests that it is rare, but no doubt undercollected.

Conservation issues: Most sites are probably on private land at lower elevations, and protection may only be possible on federal land. So little is known about the distribution of this species that all known localities should be checked to reconfirm presence of populations, and the habitats characterized. New populations should be sought throughout the region. Stands with known populations should be protected until the distribution and habitat is clarified.



Tripterocladium leucocladulum. -- 1. Plant and detail of shoot. -- 2. Leaves, showing varaiation in costa, from single, to short and double, to none. -- 3. Cells in alar region of leaf. -- 4. Cells in middle of leaf. -- 5. Cells at tip of leaf. -- 6. Capsules. From Brotherus (1909), Grout (1932) and Lawton (1971). Figures from Lawton (1971) reprinted with permission of the Hattori Botanical Laboratory.

TRIQUETRELLA CALIFORNICA (Lesq.) Grout
Three-ranked knob moss
Recent synonyms: None



Status: ONHP List 3.

Distribution: Endemic to western North America. Known only from scattered localities near the coast, southwestern Oregon to southern California.

Habitat and ecology: Forming loose mats on exposed to shaded soil, rocks or sand, in dry or moist situations. Reported from trails, roadsides, picnic areas and rock outcrops. In coastal shore pine and Sitka spruce forest at the north end of its range, and in dense chaparral on north-facing slopes at the southern end of its range (Stark 1980). Associated species seen include *Racomitrium heterostichum* and *Cladonia*.

Description: Plants ascending or trailing, 1-3 cm long, branched irregularly, branches threadlike, 0.5-0.75 mm wide. Leaves yellow-green to yellowish-brown, straight and imbricate when dry, with flexuose tips, lanceolate. When wet, leaves erect-spreading to squarrose, spiraling up the stem in three longitudinal rows. Costa prominent at back of leaf. Margins of leaves conspicuously recurved. Leaf cells rounded, thick-walled, with tall, often forked papillae. Capsules have never been found.

Distinctive characters: (1) Leaves, when wet, spiraling up the stem in three distinct rows, (2) the leaf cells with tall, often forked papillae

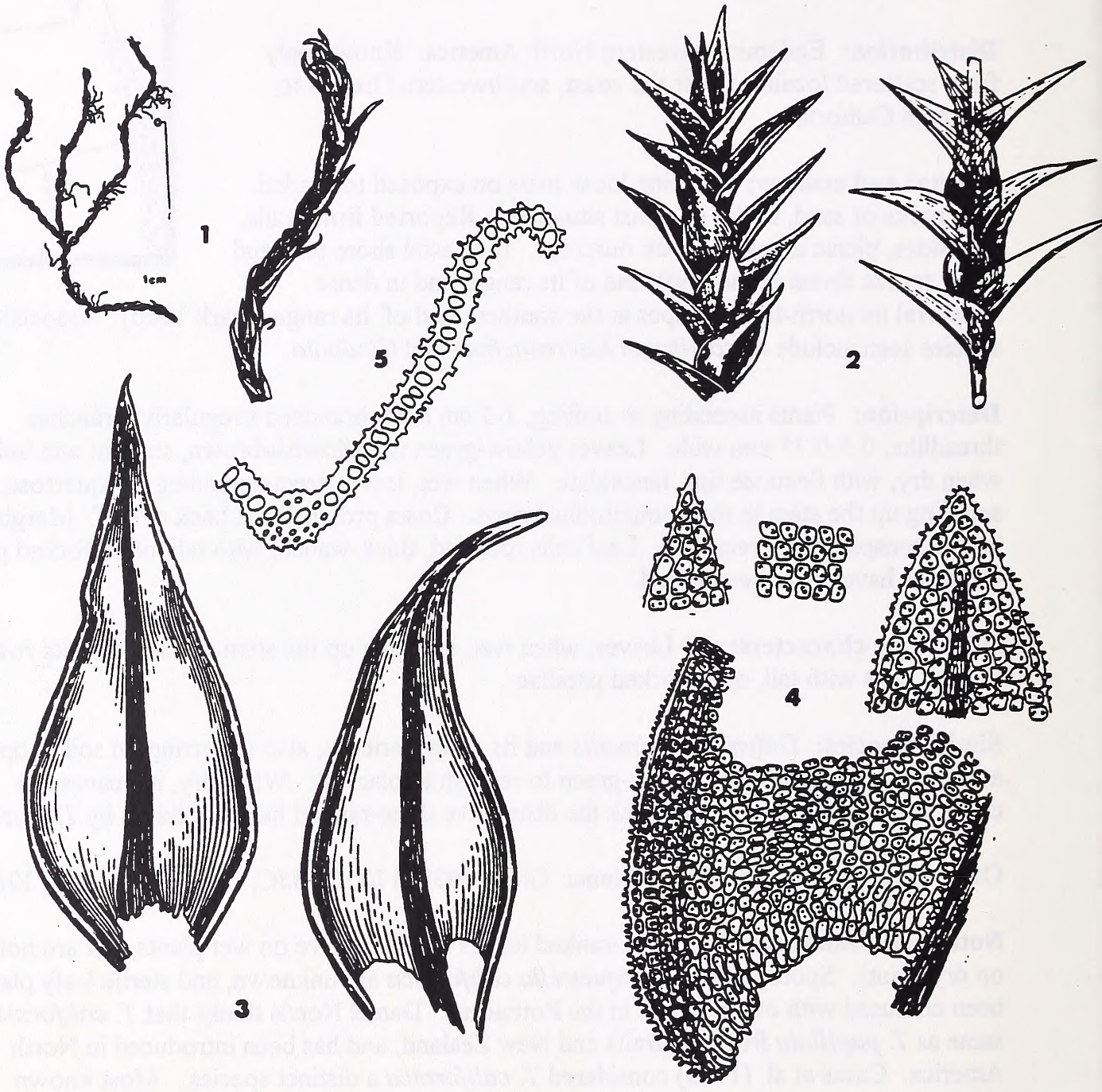
Similar species: *Didymodon vinealis* and its many varieties, also occurring on soil in open areas, range in color from yellow-green to reddish to blackish. When dry, its leaves are contorted, and when wet, they lack the distinctive three-ranked habit exhibited by *Triquetrella*.

Other descriptions and illustrations: Grout 1938: 170, *Pl. 83C*; Casas et al. 1993: 126.

Notes and comments: The three-ranked leaves are distinctive on wet plants, but are not obvious on dry plants. Sporophytes of *Triquetrella californica* are unknown, and sterile leafy plants have been confused with other genera in the Pottiaceae. Daniel Norris thinks that *T. californica* is the same as *T. papillata* from Australia and New Zealand, and has been introduced in North America. Casas et al. (1993) considered *T. californica* a distinct species. Most known populations are on private land or in state parks, but at least one is known from Redwood National Park.

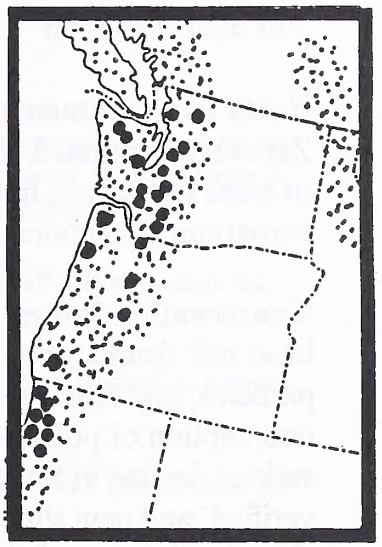
Conservation issues: Threats to the taxon are overcollection and commercial development, including development of recreational facilities on public lands. The best opportunity for protection would be on federal land, and in state parks where natural area protection is possible.

Known localities should be revisited, and the status of the populations monitored. New populations should be sought on federal lands and in protected areas in state parks. Some populations appear to exist in disturbed areas, and seem to be able to coexist with moderate recreational traffic.



Triquetrella californica. -- 1. Plant and detail of shoot. -- 2. Detail of wet shoots; schematic drawing on right shows ranking of leaves. -- 3. Leaves, showing recurved margins. -- 4. Cells at tip, middle and base of leaf, showing papillae. -- 5. Cross-section of leaf, showing papillae and recurved margin. From Grout (1938) and Casas et al. (1993). Figures from Casas et al. (1993) reprinted with permission of the American Bryological and Lichenological Society.

ULOTA MEGALOSPORA Vent. *in* Röll
Giant-spored tree moss
Recent synonyms: None



Status: SAT Appendix 5-H; FEMAT Appendix Table IV-A-3.

Distribution: Endemic to the Pacific Northwest. Southeastern Alaska, British Columbia, Washington, Oregon, Idaho, northern California. Map in Vitt et al. (1988), showing occurrence in Yukon, is in error (Ireland et al. 1987).

Habitat and ecology: Epiphytic on conifers and hardwoods, particularly maples, alder and tan oak. On both trunks and branches, especially toward the tips, where competition from other bryophytes is less intense. Lowlands to montane, but not subalpine.

Description: Plants green to yellow-green, with inconspicuous prostrate, creeping stems and erect, bushy branches 0.5-1(1.5) cm tall, forming clumps. Leaves narrowly lanceolate from a spoon-shaped base, 1-2(4) mm long, crisped when dry, erect-spreading when wet, with long, slender, tapering apices; margins plane or sometimes recurved; costa ending before the apex. Leaf cells papillose, the upper ones rounded to shortly elongate, 7-9 μm in diameter, thick-walled, the basal cells elongate, 2-4:1. Setae (1)2-3.5(4) mm long. Capsules exserted, 1.5-2.2 mm long, with 8 conspicuous longitudinal ribs when dry, stomates occurring on the surface of the capsule wall, in the middle of the capsule, well above the neck; outer peristome teeth reflexed against wall of capsule when dry. Calyptra bell-shaped, wrinkled longitudinally, with long, bristly hairs. Spores large, 30-60μm.

Distinctive characters: (1) small (<2 cm) erect, bushy cushions on twigs and branches, with (2) crisped leaves, (3) hairy calyptrae, (4) longitudinally ribbed capsules, and (5) stomates on the surface of the capsule, occurring in the middle of the capsule instead of the neck.

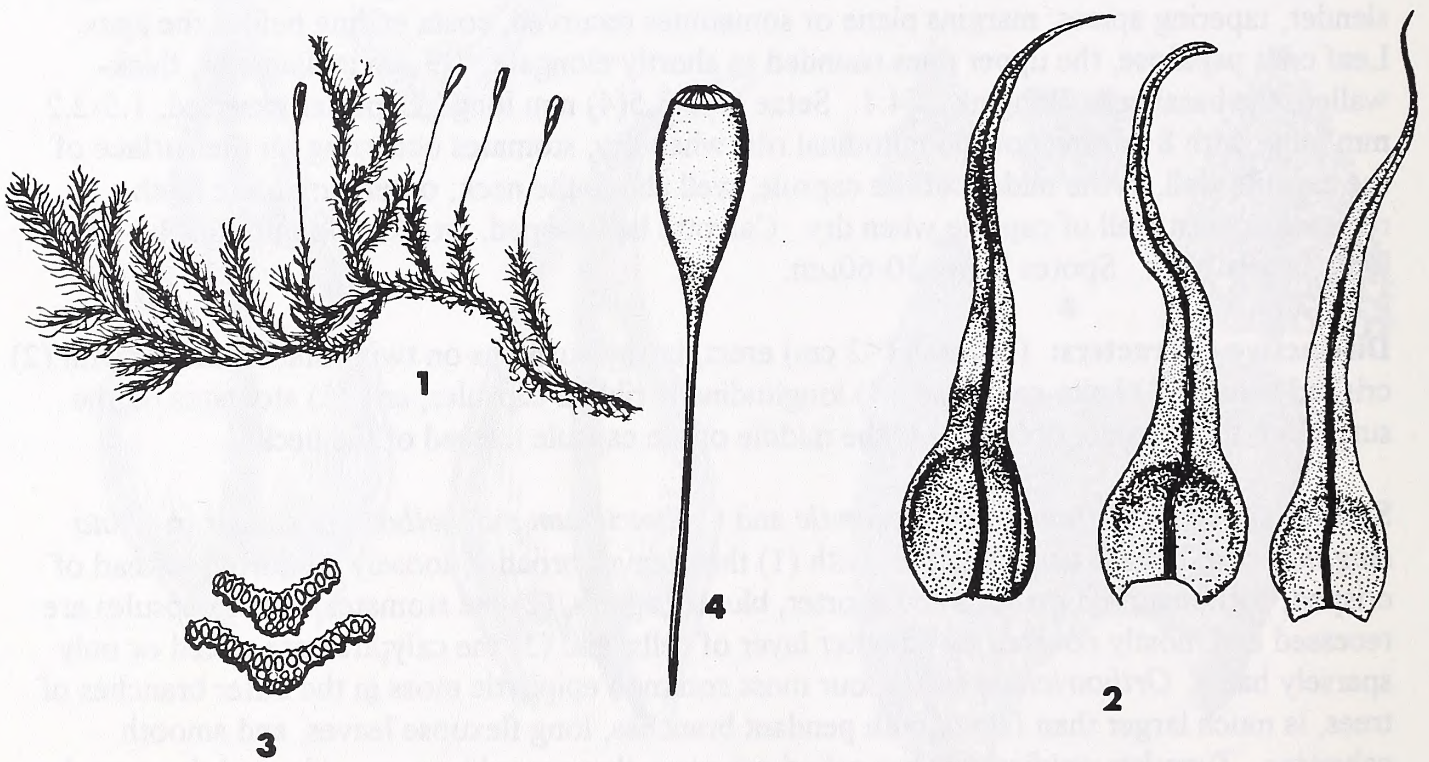
Similar species: *Orthotrichum consimile* and *Orthotrichum pulchellum* are similar to *Ulota megalospora*, but are usually larger, with (1) their leaves broader, loosely contorted instead of crisped, with recurved margins and shorter, blunter apices, (2) the stomates on the capsules are recessed and mostly covered by an outer layer of cells, and (3) the calyptrae are naked or only sparsely hairy. *Orthotrichum lyellii*, our most common epiphytic moss in the outer branches of trees, is much larger than *Ulota*, with pendant branches, long flexuose leaves, and smooth calyptrae. *Zygodon viridissimus* has naked calyptrae that are split on one side, and the capsules lack a peristome. However, *Zygodon* is usually sterile, so one has to rely on leaves, which differ from *Ulota* in being less long-attenuate, slightly broader, more strongly papillose, and often having multicellular gemmae in the leaf axils. *Ulota megalospora*, as the name suggests, beats all of these similar species with its huge spores.

Other descriptions and illustrations: Grout 1935: 135, *Pl. 57C*; Lawton 1971: 229, *Pl. 126*;

Vitt et al. 1988: 66

Notes and comments: *Ulota megalospora*, together with the species of *Orthotrichum* and *Zygodon* mentioned above, form a distinctive group of epiphytes on trunks, branches and twigs of trees and shrubs in low to middle-elevation forests. *Ulota* and *Zygodon* are uncommon in herbarium collections, and appear to be less common than the *Orthotrichum* species.

Conservation Issues: *Ulota megalospora* and the other epiphytic mosses associated with it may be at risk from air pollution. Their tufted growth form makes them efficient trappers of airborne particles, and their location on branches near the edge of the forest canopy is the first site of interception of polluted air. Hallingbäck (1992) noted that *Ulota* was one of the genera in serious decline in Sweden due to air pollution. Sites where it is known to occur need to be verified, and new sites need to be sought. It is not clear if this species is restricted to certain elevations, or certain host tree species. It is a prime candidate for monitoring the effects of air pollution. Loss of sites on private land may elevate its status on federal lands.



Ulota megalospora. -- 1. Plant. -- 2. Leaves, showing spoon-shaped base. -- 3. Cross-sections of leaves, showing papillae. -- 4. Capsule. From Grout (1935).

GLOSSARY OF TERMS USED FOR MOSSES

Acrocarpous. Producing capsules at the tip of a main stem or branch. Last year's capsule may appear to be lateral, because the shoot has grown beyond the old point of attachment. Most species are erect, with relatively few or no branches, and are often pioneers on disturbed sites. Opposite of *pleurocarpous*.

Alar cells. Those cells at the outer bases of leaves, where they join the stem. They usually differ from cells in the middle of the leaf.

Annulus. A gasket-like ring of specialized cells attaching the operculum to the capsule. When the capsule matures, the annulus peels back, and the operculum falls off.

Antheridia. Plural of *antheridium*; the male structure producing motile sperm cells that swim in a film of water to the archegonium, and there fertilize the egg. Opposite of *archegonium*.

Apiculus. A short point, usually formed by an extension of the costa, projecting beyond an otherwise blunt or rounded leaf tip.

Appressed. With leaves pressed close to the stem, usually when plants are dry. Opposite of *spreading*.

Archegonia. Plural of *archegonium*; the female structure producing eggs, much like ovules in the pistil of flowering plants. Sperm cells from the antheridium swim down the neck of the archegonium to fertilize the egg. The fertilized egg (zygote) then produces the seta and the capsule. Opposite of *antheridium*.

Awn. A hair-like point projecting from the tip of a leaf. Usually formed by a costa extending beyond the tip of the leaf. Awns are usually transparent (hyaline) and variously toothed.

Beak. An elongated, narrowed tip on an operculum. Also called a *rostrum*.

Bistratose. Composed of two layers of cells, when seen in cross-section. See also *multistratose* and *bistratose*.

Calyptra. The membranous cap situated on top of the operculum, and usually falling off before capsules mature. It is a remnant of the archegonium, hoisted aloft by the developing seta.

Capsule. A composite term for the structure supported by the seta. Depending on the species, it variously includes a neck region at the top of the seta, the urn where the spores are produced, the annulus, operculum and calyptra. There is great variation among taxa in the shape of the capsule and the number of components present.

Circinate. A leaf so strongly curved or curled that it nearly forms a circle.

Columella. A column of freestanding tissue in the center of a capsule, extending for most of the capsule's length, around which the spores develop. In immature capsules, the operculum is attached to the columella. In a few species, the operculum remains attached to the columella, the two resembling an umbrella protruding above the capsule.

Complanate. Leaves flattened in two rows opposite each other on the stem, like the blade of a fern or feather.

Contorted. Leaves irregularly bent or twisted in various directions; not as tightly coiled as in *crisped*.

Cortical. Pertaining to the cortex, the outer layers of cells in a stem or branch. In mosses, these are usually thick-walled and often darker than the central cells.

Costa. The midrib of a leaf, sometimes short and double, sometimes extending beyond the tip as a long awn, or sometimes altogether absent.

Costate. Leaves having a costa. Opposite of *ecostate*.

Crenate. Leaves with microscopic, irregular rounded teeth that give the edges a roughened appearance.

Crisped. Leaves tightly coiled or twisted in various directions; more tightly coiled than in *contorted*.

Dendroid. Plants having the form of a small tree.

Decurrent wing. The outer basal part of a leaf that, in some species, extends down the stem, forming a line of leaf tissue.

Dioicous. Having antheridia (male) and archegonia (female) organs on separate plants, like *dioecious* in vascular plants.

Epiphragm. A membrane covering the opening of the capsule in *Polytrichum* and other members of the Polytrichaceae. It looks much like the head of a drum. The spores are released between small teeth attaching the edge of the epiphragm to the capsule, much like a salt shaker.

Exserted. An object protruding beyond something that surrounds it, like a capsule protruding from a cluster of leaves, or an awn extending beyond the tip of a leaf.

Falcate. Leaves curved like a sickle; not as tightly curved as in *circinate*.

Flexuose. Bent in various divergent angles, like the tips of leaves.

Hyaline. Transparent, like frosted glass.

Hypophysis. The conspicuously swollen neck of a capsule, located just below the urn. *Splachnum ampullaceum* is an excellent example.

Imbricate. With leaves appressed to the stem and overlapping each other, usually when dry.

Incurved. With margins of leaves curved or curled inward toward each other, over the surface of the leaf facing the stem. Opposite of *recurved*.

Lamellae. Parallel sheets of cells growing out from the costa, and extending for part or all of its length, appearing in cross-section as lines or chains of cells emanating from the costa, usually on the side of the leaf facing the stem. Lamellae are thought to help retain water on the leaves, and they increase the leaves' photosynthetic surface. The lamellae grow at right angles to the leaf surface in *Polytrichum*, but nearly parallel to it in *Pterygoneurum*.

Lanceolate. Leaves shaped like the tip of a lance, widest below the middle and tapering to a point.

Multistratose. Composed of more than two layers of cells, when viewed cross-section. See also *bistratose* and *unistratose*.

Operculum. The lid on the capsule of a moss, usually falling off when the capsule matures, but occasionally remaining attached to the columella.

Papillae. Microscopic outgrowths in cell walls that ornament various parts of moss plants. They range from simple

bumps like pimples, to C-shaped or even branched, antleroid structures. Depending on the species, they can occur almost anywhere on the plant, even on rhizoids and spores, and are important taxonomic characters. On leaves, papillae are thought to help retain water.

Papillose. Having papillae. Opposite of *smooth*.

Paroicous. Having antheridia and archegonia on the same plant, but in different locations.

Paraphyllia. Green, leafy or filamentous outgrowths from stems or bases of leaves, looking like green felt among the stem leaves. Paraphyllia help move and retain water on the stems, through capillary action, and they increase the plants' photosynthetic surface. They are most common on pleurocarpous mosses. Do not confuse with rhizoids, which are never green.

Perichaetium. A cluster of specialized leaves surrounding the archegonia. After fertilization and development of the capsule, perichaetia remain at the base of the seta.

Peristome. A set of membranous teeth surrounding the opening of the capsule. The teeth open and close with variations in local humidity, and regulate the liberation of spores from the capsule. Number, shape and ornamentation of the teeth vary greatly with different taxa, and are altogether absent from some species. The peristome is one of the most important characters in the study of the evolution of mosses, because it varies little with environment, whereas the leafy plant can be greatly influenced by environment.

Pinnate. With branches spreading nearly opposite each other along the stem, like a feather.

Pitted. Microscopic thinnings in the walls of leaf cells, particularly in the alar and basal region.

Pleurocarpous. Plants producing capsules on lateral branches instead of at the tip of the shoot, with the plants usually prostrate and creeping. Opposite of *acrocarpous*.

Propagulae. Specialized cells (*propagules)* produced for vegetative propagation. They may be form powdery, grape-like clusters of individual cells, filamentous chains, or tiny flat plates produced in specialized *splash cups*, as in *Tetraphis*. Also called *gemmae*.

Recurved. With margins of leaves curved or curled backward, over the surface of the leaf facing away from the stem. Opposite of *incurved*.

Rhizoids. Brownish, reddish or whitish, filamentous growths at the base of stems, but occasionally forming felts extending up the stems. They serve to anchor the plants to the substrate, and help move and retain water through capillary action. Do not confuse with *paraphyllia*, which are always green.

Secund. Leaves all pointing in one direction, as if in a stiff breeze.

Serrulate. With microscopic teeth along the margins of leaves.

Seta. The stalk supporting the capsule, elongate in most species, but much reduced in others.

Sinuouse. Cells with wavy walls.

Splash cup. A specialized structure designed to disperse vegetative propagulae or sperm cells. When a drop of water lands in the cup, it splashes out again in all directions, carrying propagulae (as in *Tetraphis*) or sperm cells (as in *Polytrichum*).

Squarrose. Leaves curved backwards on the stem, so the tips are nearly at right angles to the stem.

Stomata. Specialized openings in a photosynthetic surface designed to regulate gas exchange. In mosses, stomata occur only on capsules.

Striate. With minute, longitudinal ridges.

Turgid. Shoots and leaves swollen and expanded, especially when wet.

Unistratose. Composed of one layer of cells, when viewed in cross-section. See also *bistratose* and *multistratose*.

Urn. The portion of the capsule in which the spores form, and from which they are liberated at maturity.

PART VIII. LITERATURE CITED

Amakawa, T. 1959. Family Jungermanniaceae of Japan. J. Hattori Bot. Lab. 21: 248-291.

Anderson, L.E., H.A. Crum & W.R. Buck. 1990. List of the mosses of North America north of Mexico. Bryologist 93: 448-499.

Andrews, A.L. 1935. Family Bryaceae. Pp. 184-210 *in* : Grout, A.J. *Moss Flora of North America North of Mexico*. Vol. 2. Published by the author. Newfane, Vermont.

Andrus, R.E., E.F. Karlin & S.S. Talbot. 1992. Rare and endangered *Sphagnum* species in North America. Biol. Conserv. 59: 247-254.

Bates, J.W. 1992. Mineral nutrient acquisition and retention by bryophytes. J. Bryol. 17: 223-240.

Brotherus, V.F. 1909. Musci. Pp. 277-1246 *in*: A. Engler & K. Prantl (eds.). *Die natürlichen Pflanzenfamilien.* 1st ed. Teil 1, Abt. 3, Heft 1 & 2. Leipzig. Verlag von W. Engelmann.

Brown, D.H. & J.W. Bates. 1990. Bryophytes and nutrient cycling. Bot. J. Linn. Soc. 104: 129-147.

Bursik, R.J. 1993. Fen vegetation and rare plant monitoring in Cow Creek Meadows and Smith Creek Research Natural Area, Selkirk Mountains, Idaho. Report to Idaho Panhandle National Forests. Idaho Dept. Fish and Game, Conservation Data Center. 25 pp. + appendix.

_____ & R.K. Moseley. 1992a. Vegetation and water chemistry monitoring and twenty-year floristic changes at Huff Lake Fen, Kaniksu National Forest [Pend Oreille Co., Washington]. Report to Idaho Panhandle National Forests. Idaho Dept. Fish and Game, Conservation Data Center. 26 pp. + appendix.

_____ & R.K. Moseley. 1992b. Forty-year changes in Hager Lake Fen, Bonner County, Idaho. Report to Idaho Panhandle National Forests. Idaho Dept. Fish and Game, Conservation Data Center. 31 pp.

Campbell, A.G. 1973. Vegetative ecology of Hunts Cove, Mt. Jefferson, Oregon. M.S. thesis. Oregon State Univ., Corvallis. 89 pp.

Casas, C., R.M. Cros & J. Muñoz. 1993. *Triquetrella arapilensis* y especies afines: su morfología y distribución geográphica. Bryologist 96: 122-131.

Christy, J.A. 1987. *Limbella fryei* (Williams) Ochyra distinct from *L. tricostata* (Sull.) C.M. (Musci: Amblystegiaceae). J. Hattori Bot. Lab. 63: 395-410.

Churchill, S.P. 1985. The systematics and biogeography of *Scouleria* Hook. (Musci: Scouleriaceae). Lindbergia 11: 59-71.

Conard, H.S. 1944. *Brotherella roellii* (R. & C.) Fleischer. Bryologist 47: 194-195.

Crum, H. 1983. Mosses of the Great Lakes Forest. 3rd ed. Univ. Michigan Herbarium, Ann Arbor. 417 pp.

_____ & L.E. Anderson. 1981. *Mosses of Eastern North America*. 2 vols. Columbia University Press, New York. 1328 pp.

During, H.J. & B.F. van Tooren. 1990. Bryophyte interactions with other plants. Bot. J. Linn. Soc. 104: 79-98.

Eddy, A. 1988. *A Handbook of Malesian Mosses*. Vol. 1. Sphagnales to Dicranales. British Museum, London. 204 pp.

Evans, A. W. 1915. Notes on North American Hepaticae. VI. Bryologist 18: 81-91.

Flowers, S. 1935. Family Bartramiaceae. Pp. 152-180 *in*: Grout, A.J. *Moss Flora of North America North of Mexico*. Vol. 2. Published by the author. Newfane, Vermont.

_____. 1973. *Mosses: Utah and the West*. Brigham Young University Press, Provo, Utah. 567 pp.

Forest Ecosystem Management Assessment Team. 1993. Forest ecosystem management: an ecological, economic, and social assessment. USDA Forest Service, Portland, Oregon.

Frahm, J.-P. 1980. Synopsis of the genus *Campylopus* in North America north of Mexico. Bryologist 83: 570-588.

_____. 1984. A survey of the genus *Campylopus* Brid. in Sri Lanka. J. Bryol. 13: 163-191.

_____. 1987. Survey of *Campylopus* species of Australia. J. Bryol. 14: 701-727.

_____ & H. Mohamed. 1987. Survey of *Campylopus* and *Bryohumbertia* (Dicranaceae) of Malaysia. Mem. New York Bot. Gard. 45: 470-491.

Frenkel, R.E., W.H. Moir & J.A. Christy. 1986. Vegetation of Torrey Lake Mire, central Cascade Range, Oregon. Madrono 33: 24-39.

Frisvoll, A.A. 1988. A taxonomic revision of the *Racomitrium heterostichum* group (Bryophyta, Grimmiales) in N. and C. America, N. Africa, Europe and Asia. Gunneria 59: 1-289.

Frye, T.C. 1910. The Polytrichaceae of western North America. Proc. Washington Acad. Sci. 12: 271-328.

_____. 1937. Family Polytrichaceae. Pp. 99-128 *in*: Grout, A.J. *Moss Flora of North America North of Mexico*. Vol. 1. Published by the author. Newfane, Vermont.

_____ & L. Clark. 1937. Hepaticae of North America. No. 1. University of Washington Publications in Biology 6: 1-162.

_____ & L. Clark. 1943. Hepaticae of North America. No. 2. University of Washington Publications in Biology 6: 163-336.

_____ & L. Clark. 1945. Hepaticae of North America. No. 3. University of Washington Publications in Biology 6:337-564.

_____ & L. Clark. 1946. Hepaticae of North America. No. 4. University of Washington Publications in Biology 6: 565-733.

_____ & L. Clark. 1947. Hepaticae of North America. No. 5. University of Washington Publications in Biology 6: 735-1022.

Godfrey, J.D. 1976. *Schofieldia*, a new hepatic from the Pacific Northwest. Bryologist 79: 314-320.

_____. 1977. New and interesting hepatics from British Columbia, Canada, and northern Washington State, U.S.A. I. Bryologist 80: 539-543.

_____ & G.A. Godfrey. 1980. Notes on Hepatics from the Pacific Northwest. Bryologist 83: 224-228.

Griffin, L.E. & E. Thurston. 1935. Notes on Oregon Liverworts. Northw. Sci. 9: 24.

Grout, A.J. 1903. *Mosses with Hand-lens and Microscope*. Privately published, New York. 416 pp.

_____. 1928-1941. *Moss Flora of North America North of Mexico*. 3 vols. Published by the author. Newfane, Vermont.

Hallingbäck, T. 1992. The effect of air pollution on mosses in southern Sweden. Biol. Conserv. 59: 163-170.

Harthill, M.P. & O'Connor, I. 1975. *Common Mosses of the Pacific Coast*. Naturegraph Publishers, Healdsburg, CA. 119 pp.

Hattori, S. & M. Mizutani. 1958. A revision of the Japanese species of the family Lepidoziaceae. J. Hattori Bot. Lab. 19: 76-118.

Hong, W.S. 1980. The genus *Scapania* in western North America. II. Taxonomic treatment. Bryologist 83: 40-59.

_____. 1980a. Hepaticae of the North Cascades Range, Washington. Bryologist 83: 94-102.

_____. 1982. The genus *Marsupella* in western North America. Lindbergia 8: 166-176.

_____. 1983. The genus *Porella* in North America west of the Hundredth Meridian. Bryologist 86-143-155.

_____. 1986. The family Cephaloziellaceae in North America west of the hundredth meridian. Bryologist 89: 155-162.

_____. 1988. The family Lepidoziaceae in North America west of the hundredth meridian. Bryologist 91: 326-333.

_____. 1990. The family Calypogeiaceae in North America west of the hundredth meridian. Bryologist 93: 313-318.

_____. 1992. *Plagiochila* in western North America. Bryologist 95: 142-147.

_____. 1993. The family Geocalycaceae (Hepaticae) in North America, west of the hundredth meridian. Bryologist 96: 592-597.

_____. 1994. *Tritomaria* in western North America. Bryologist 97: 166-170.

_____, K. Flander, D. Stockton, & D. Trexler. 1989. An annotated checklist of the liverworts and hornworts of Olympic National Park, Washington. Evansia 6: 33-52.

Horton, D.G. 1983. A revision of the Encalyptaceae (Musci), with particular reference to the North American taxa. Part II. J. Hattori Bot. Lab. 54: 353-532.

_____ & B.M. Murray. 1976. *Encalypta brevipes* and *E. mutica*, gymnostomous species new to North America. Bryologist 79: 321-331.

Howe, M.A. 1899. The Hepaticae and Anthocerotes of California. Mem. Torrey Bot. Club 7: 1-208.

Inuoe, H. 1958. The family Plagiochilaceae of Japan and Formosa. J. Hattori Bot. Lab. 19: 25-59.

_____. 1965. Contributions to the knowledge of the Plagiochilaceae of Southeastern Asia VI. Studies on the *Plagiochila semidecurrens* complex. J. Hattori Bot. Lab. 28. 209-218.

_____. 1974. Illustrations of Japanese Hepaticae, Vol. I. Tsukijii Shokan Publ. Co., Ltd., Tokyo.

_____. 1976. Illustrations of Japanese Hepaticae, Vol. II. Tsukijii Shokan Publ. Co., Ltd., Tokyo.

Ireland, R.R. 1982. *Moss Flora of the Maritime Provinces*. Nat. Mus. Nat. Sci., Publ. Bot. 13: 1-738. National Museum of Natural Sciences, Ottawa.

_____ & J.R. Spence. 1987. *Racomitrium pacificum*, a new moss species from western North America. Can. J. Bot. 65: 859-862.

_____, R.R., G.R. Brassard, W.B. Schofield & D.H. Vitt. 1987. Checklist of the mosses of Canada II. Lindbergia 13: 1-62.

Jones, G.N. 1933. Family Grimmiaceae. Pp. 1-60 *in*: Grout, A.J. *Moss Flora of North America North of Mexico*. Vol. 2. Published by the author. Newfane, Vermont.

Kimmerer, R.W. & C.C. Young. 1995. The role of slugs in dispersal of the asexual propagules of *Dicranum flagellare*. Bryologist 98: 149-153.

Kitagawa, N. 1965. Lophoziaceae of Japan. I. J. Hattori Bot. Lab. 28: 237-291.

_____. 1966. Lophoziaceae of Japan. II. J. Hattori Bot. Lab. 29: 101-149.

Koch, L.F. 1951. *Fissidens pauperculus* Howe and *Orthodontium gracile* Bruch & Schimper: mosses associated with the coast redwood forest. Science 114: 571.

_____. 1952. Bryophytes of Chetco River Redwood State Park, Oregon. Madrono 11: 209-214.

Koponen, T. 1973. *Rhizomnium* (Mniaceae) in North America. Ann. Bot. Fenn. 10: 1-26.

Kuwahara, Y. 1976. *Metzgeria temperata*, a new holarctic species of Hepaticae. J. Hattori Bot. Lab. 40: 217-220.

Laaka, S. 1992. The threatened epixylic bryophytes in old primeval forests in Finland. Biol. Conserv. 59: 151-154.

Lavin, M. 1982. Distribution of the moss family Grimmiaceae in Nevada. Great Basin Nat. 42: 583-588.

Lawton, E. 1971. *Moss Flora of the Pacific Northwest.* Hattori Botanical Laboratory, Nichinan, Japan. 362 pp.

Leiberg, J.B. 1892. Some notes on *Tripterocladium leucocladulum*, Muell. Bull. Torrey Bot. Club 19: 7-9.

Lesher, R.D., R. Rosentreter & J. Christy. 1994. The role of fungi, lichens, and bryophytes in the development of management alternatives for federal lands in the Pacific Northwest. [Abstract]. Northwest Science 68: 136.

Lesica, P., B. McCune, S.V. Cooper & W.S. Hong. 1991. Differences in lichen and bryophyte communities between old-growth and managed second-growth forests in the Swan Valley, Montana. Can. J. Bot. 69: 1745-1755.

MacKinnon, A., J. Pojar & R. Coupé (eds.). 1992. *Plants of Northern British Columbia.* Lone Pine Publishing, Vancouver, B.C. 344 pp.

Maleug, K.W, J.R. Tilstra, D.W. Schults and C.F. Powers. 1972. Limnological observations on an ultra-oligotrophic lake in Oregon, USA. Verhandlungen Internationale Vereinigung für Theoretische und Angewandte Limnologie 18: 292-302.

Master, L.L. 1991. Assessing threats and setting priorities for conservation. Conserv. Biol. 5: 559-563.

McCune, B. 1977. Vegetation development on a low elevation talus slope in western Montana. Northw. Sci. 51: 198-207.

_____. 1994. New field tools. Evansia 11: 159.

Miller, H.A. 1967. Oddments of Hawaiian bryology. J. Hattori Bot. Lab. 30: 271-276.

_____. 1965. A review of *Herberta* in the tropical Pacific and Asia. J. Hattori Bot. Lab. 28: 299-412.

_____ & S. Shushan. 1964. The 1962 foray in Oregon of the American Bryological Society. Bryologist 67: 60-72.

Müller, K. 1954. Die Lebermoose Europas. Part 1. *in* Rabenhorst's Kryptogamen Flora, Vol. VI, 3rd ed. Leipzig.

_____. 1957. Die Lebermoose Europas. Part 2. *in* Rabenhorst's Kryptogamen Flora, Vol.

VI, 3rd ed. Leipzig.

Murray, B.M. 1987. *Andreaea schofieldiana* and *A. megistospora*, species novae, and taxonomic criteria for Sect. *Nerviae* (Andreaeopsida). Bryologist 90: 15-26.

Nadkarni, N.M. 1984. Biomass and mineral capital of epiphytes in an *Acer macrophyllum* community of a temperate moist coniferous forest, Olympic Peninsula, Washington State. Can. J. Bot. 62: 2223-2228.

Nash, T.H., S.L. White & J.E Marsh. 1977. Lichen and moss distribution and biomass in hot desert ecosystems. Bryologist 80: 470-479.

Noguchi, A. 1987-1994. *Illustrated Moss Flora of Japan*. 5 vols. Hattori Botanical Laboratory. Nichinan, Japan. 1253 pp.

Norris, D.H. 1987. Long-term results of cutting on the bryophytes of the *Sequoia sempervirens* forest in northern California. Symp. Biol. Hungarica 35: 467-473.

_____. 1990. Bryophytes in perennially moist forests of Papua New Guinea: ecological orientation and predictions of disturbance effects. Bot. J. Linn. Soc. 104: 281-291.

Nyholm, E. 1954-1969. *Illustrated Moss Flora of Fennoscandia*. Vol. 2. Musci. CWK Gleerup, Lund, and Natural Science Research Council, Stockholm. 799 pp.

Ochyra, R. 1987. On the taxonomy and family placement of the moss genus *Limbella* (C. Muell.) Broth. J. Bryol. 14: 465-485.

Oregon Natural Heritage Program. 1995. *Rare, Threatened and Endangered Plants and Animals of Oregon*. Oregon Natural Heritage Program, Portland. 84 pp.

Osada, T. 1965. Japanese Polytrichaceae 1. Introduction and the genus *Pogonatum*. J. Hattori Bot. Lab. 28: 171-201.

Peck, J.E., W.S. Hong & B. McCune. 1995. Diversity of epiphytic bryophytes on three host tree species, Thermal Meadow, Hotsprings Island, Queen Charlotte Islands, Canada. Bryologist 98: 123-128.

Pojar, J. & A. MacKinnon (eds.). 1994. *Plants of the Pacific Northwest Coast*. Lone Pine Publishing, Vancouver, B.C. 526 pp.

Rushing, A.E. 1986. A revision of the genus *Bruchia* Schwaegr. (Musci). J. Hattori Bot. Lab. 60: 35-83.

Sanborn, E.I. 1929. Hepaticae and Anthocerotes of western Oregon. University of Oregon

Publications, Plant Biol. Ser. 1: 1-111.

Sayre, G. 1935. Family Splachnaceae. Pp. 89-102 *in*: Grout, A.J. *Moss Flora of North America North of Mexico*. Vol. 2. Published by the author. Newfane, Vermont.

Schofield, W.B. 1966a. A new species of *Trematodon* from western North America. Bryologist 69: 202-204.

_____. 1966b. *Crumia*, a new genus of the Pottiaceae endemic to western North America. Can. J. Bot. 44: 609-614.

_____. 1968. Bryophytes of British Columbia II Hepatics of particular interest. J. Hattori Bot. Lab. 31: 265-282.

_____. 1985. *Introduction to Bryology*. Macmillan Publishing Co., New York. 431 pp.

_____. 1992. *Some Common Mosses of British Columbia*. Royal British Columbia Museum, Victoria. 394 pp.

_____. 1994. Rare and endangered bryophytes in British Columbia. Pp. 71-75 *in*: L.E. Harding & E. McCullum (eds.). Biodiversity in British Columbia: our changing environment. Canadian Wildlife Service, Ministry of the Environment. 426 pp.

_____ & G.A. Godfrey. 1979. *Radula brunnea* Steph. in western North America. J. Hattori Bot. Lab. 46: 285-288.

Schuster, R.M. 1959a. A monograph of the Nearctic Plagiochilaceae. Part I. Introduction and Sectio 1. *Asplenioides*. Amer. Midl. Nat. 62:-1-166.

_____. 1959b. A monograph of the Nearctic Plagiochilaceae. Part II. Sectio *Zonatae* through Sectio *Parallelae*. Amer. Midl. Nat. 62: 257-395.

_____. 1966. *The Hepaticae and Anthocerotae of North America*. Vol. I. Columbia Univ. Press, New York.

_____. 1969. *The Hepaticae and Anthocerotae of North America*. Vol. II. Columbia Univ. Press, New York.

_____. 1974. *The Hepaticae and Anthocerotae of North America*. Vol. III. Columbia Univ. Press, New York.

_____. 1980. *The Hepaticae and Anthocerotae of North America*. Vol. IV. Columbia Univ. Press, New York.

_____. 1980a. Studies on Hepaticae, LIV-LVIII. J. Hattori Bot. Lab. 48:337-421.

_____. 1992. *The Hepaticae and Anthocerotae of North America*. Vol. V. Field Museum of Natural History, Chicago.

_____. 1992a. *The Hepaticae and Anthocerotae of North America*. Vol. VI. Field Museum of Natural History, Chicago.

Scientific Analysis Team. 1993. Viability assessments and management considerations for species associated with late-successional and old-growth forests of the Pacific Northwest. USDA Forest Service, Portland, Oregon. 530 pp.

Seyer, S.C. 1979. Vegetative ecology of a montane mire, Crater Lake National Park, Oregon. M.S. thesis. Oregon State Univ., Corvallis. 187 pp.

Shaw, J. 1982. *Pohlia* Hedw. (Musci) in North and Central America and the West Indies. Contr. Univ. Michigan Herb. 15: 219-295.

_____. 1991. Ecological genetics, evolutionary constraints, and the systematics of bryophytes. Adv. Bryol. 4: 29-74.

Slack, N.G. 1992. Rare and endangered bryophytes in New York State and eastern United States: current status and preservation strategies. Biol. Conserv. 59: 233-241.

Smith, A.J.E. 1978. *The Moss Flora of Britain and Ireland*. Cambridge Univ. Press, Cambridge. 706 pp.

_____. 1990. *The Liverworts of Britain and Ireland*. Cambridge Univ. Press, Cambridge. 362 pp.

Smith, D.K. 1980. *Funaria americana* Lindb. in North America. Bryologist 83: 335-339.

Söderström, L. 1988. The occurrence of epixylic bryophyte and lichen species in an old natural and a managed forest stand in northeast Sweden. Biol. Conserv. 45: 169-178.

Spence, J.R. 1981. Comments on the cryptogam vegetation in front of glaciers in the Teton Range. Bryologist 84: 564-568.

Spies, T.A. & J.F. Franklin. 1988. Coarse woody debris in Douglas-fir forests of western Oregon and Washington. Ecology 69: 1689-1702.

Stark, L.R. 1980. *Triquetrella* in North America. Bryologist 83: 363-364.

Steele, A. 1978. Bryophyte communities of central Idaho forests. Northw. Sci. 52: 310-322.

Stoneburner, A., R. Wyatt & I.J. Odrzykoski. 1991. Applications of enzyme electrophoresis to bryophyte systematics and population biology. Adv. Bryol. 4: 1-27.

_____, D.M. Lane & L.E. Anderson. 1992. Spore dispersal distances in *Atrichum angustatum* (Polytrichaceae). Bryologist 95: 324-328.

Stotler, R. & B. Crandall-Stotler. 1977. A checklist of the liverworts and hornworts of North America. Bryologist 80: 405-428.

Tan, B.C. 1983. The status of *Campylopus hemitrichus* (C. Muell.) Jaeg. Cryptogamie, Bryol. Lichénol. 4: 357-361.

USDA Forest Service & USDI Bureau of Land Management. 1994a. Final supplemental environmental impact statement on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. 2 vols. + appendices. USDA Forest Service, Portland, Oregon.

_____ & _____. 1994b. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl. 73 pp. + Standards and Guidelines. USDA Forest Service, Portland, Oregon.

Vitt, D.H., J.E. Marsh & R.B. Bovey. 1988. *Mosses, Lichens & Ferns of Northwest North America.* University of Washington Press, Seattle. 296 pp.

Watson, E.V. 1968. *British Mosses and Liverworts.* 2nd ed. Cambridge Univ. Press, Cambridge. 495 pp.

Williams, R.S. 1933. *Sciaromium fryei* sp. nov. Bryologist 35: 52-53.

Wilson, C.E. 1986. Floristic and edaphic aspects of vegetational patterns in subalpine mires of the Cascade Mountains of Oregon. M.S. thesis. Univ. Oregon, Eugene. 59 pp.

Worley, I.A. 1969. *Haplomitrium hookeri* from Western North America. Bryologist 72: 225-232.

APPENDIX A: ANNOTATED BIBLIOGRAPHY OF USEFUL REFERENCES

David H. Wagner and John A. Christy, March 1995

Crum, H. 1991. *Liverworts and Hornworts of Southern Michigan*. University of Michigan Herbarium, Ann Arbor, MI 48109-1057. ISBN 0-9620733-1-8. $18.00.

One of the best book buys on this list. Howard Crum has a delightful nontechnical writing style and yet provides accurate coverage. Nice illustrations, too. Although not specifically for our area, the fact that most genera (and many species) of Michigan are also found in the PNW makes this very useful.

Crum, H. A. and L. E. Anderson. 1981. *Mosses of Eastern North America*. 2 Vols. Columbia University Press, New York. ISBN 0-231-04516-6.

This work, although restricted to the eastern half of the continent, is invaluable for working with western mosses. Perhaps 85% of our species are included. The descriptions are thorough, the keys excellent, and the illustrations marvelous. It is a serious investment: $231.99 incl. shipping via UPS. Call 1-800-944-8648.

Flowers, S. 1973. *Mosses: Utah and the West.* Brigham University Press, Provo, UT 84602. ISBN 0-8425-1524-0.

Seville Flower's posthumously published work has a reputation as being a true "best buy" among bryologists. It is still available at its original price, around $12. The discussions and illustrations are enormously useful for working with the dryland mosses of our region.

Glime, J. M. 1993. *The Elfin World of Mosses and Liverworts* [of Michigan's Upper Peninsula and Isle Royale]. Isle Royale Natural History Association. Houghton, Michigan. Paper, 148 pp. 175 color photos. ISBN 0-935289-04-6

Janice Glime has produced a nice little beginner's guide arranged by habitat. The photos are mostly very good and mostly accurate. Price is $15.95 + $4.00 shipping.

Isle Royale natural History Association
800 E. Lakeshore Drive
Houghton, MI 49931

Hicks, M.L. 1991 ('92/3?). *Guide to the Liverworts of North Carolina.* Duke University Press, Dept. HLW, 6697 College Station, Durham, NC 22708. ISBN 0-8223-1175-5

This book is a good local field guide that is useful anywhere in the country because of the widspread distribution of so many liverwort species. Price is $34.95, + $3.00 S.& H.

Lawton, E. 1971. *Moss Flora of the Pacific Northwest*. Hattori Botanical Laboratory,

Nichinan, Japan. i-xiv, 362 pp + 195 plates.

Elva Lawton's is the first and only comprehensive moss flora of our region. It contains complete descriptions, clear original illustrations, and keys to the 544 species and 54 varieties found in the region. If you're serious about mosses, this is the one you must have. Not easy to get, it must be ordered directly from Japan. Currently, (February 1995) it is on sale from Hattori Botanical Laboratory for $70.00. If you send a check drawn on a U.S. bank, add $5.00 to cover bank charges. You can get an International Postal Money Order from the Post Office, made out to Hattori's Postal Giro Account: Kagoshima 8-4277. The Post Office charges $3.00 for a money order, and you have to bring in cash. Send to:

The Hattori Botanical Laboratory
Obi, Nichinan-shi
Miyazaki-ken 899-25
JAPAN

Lawton, E. 1971. *Keys for the Identification of the mosses of the Pacific Northwest.* Hattori Botanical Laboratory, Nichinan, Japan.

This is a little booklet containing just the keys extracted from Elva Lawton's big book. It is the minimal reference for work with PNW mosses. Even if you have the big book, this is the one you keep on your microscope bench. Order as above; cost $6.00.

MacKinnon, A., J. Pojar & R. Coupé (eds.). 1992. *Plants of Northern British Columbia.* Lone Pine Publishing, Vancouver, BC and Edmonton, AB. 344 pp. ISBN 1-55105-015-3.

Much like the title by Pojar and MacKinnon described below, again with ten authors, this book treats the flora of the northern interior of B.C., roughly the northern two-thirds of the province, east of the Coast Range. Although dealing mostly with vascular plants, it describes 36 mosses, 6 liverworts, and 38 lichens. Excellent color photos supplemented by line drawings. English names are used in addition to scientific names, but distribution maps are sadly lacking. $19.95. 800-661-9017.

McQueen, C. B. 1990. *Field Guide to the Peat Mosses of Boreal North America.* University Press of New England, Hanover, NH 03755. ISBN 0-87451-522-X. $22.95

A slender book designed to fit into the pocket of a knapsack, this is a good introduction to the most common species of *Sphagnum*. This genus is notoriously difficult, and any aid will be helpful to the practicing field botanist. This book will permit identification of many species without a microscope. The excellent color photographs are sure to be appreciated.

Pojar, J. and A. MacKinnon, eds. 1994. *Plants of the Pacific Northwest Coast.* Lone Pine Publishing, Vancouver, BC and Edmonton, AB.
ISBN 1-55105-040-4

With ten authors, this is the hands-down best picture guide to the PNW flora. It includes, in addition to flowering plants, conifers and ferns, a good selection of mosses, liverworts and lichens. The photos are generally excellent. Many will appreciate that along with Latin names, English names are applied throughout (even if not truly common names). The price, $19.95, makes it a real bargain. Available at bookstores everywhere.

Schofield, W. B. 1985. *Introduction to Bryology*. Macmillan, New York. ISBN 0-02-949660-8, Macmillan Publishing Company, 866 Third Avenue, New York, NY 10022.

Wilf Schofield's book is the only decent general textbook of bryology currently available. It is popular with students, and we recommend it highly for those seriously interested in bryophytes. It prepares you for identification by presenting a comprehensive overview of bryophyte taxonomy. Currrently out of print (March 1995), it sold for around $45.00 at last check. Look for secondhand copies.

Schofield, W.B. 1992. *Some Common Mosses of British Columbia*. 2nd edition. Royal British Columbia Museum, Victoria. 394 pp. ISSN 1188-5114.

Since its first publication in 1969 (when it sold for $1.00!), this book has been the best popular guide to mosses west of the Cascade Range. More than 120 species are described in the new edition, illustrated with line drawings. Keys and phytogeographical discussions were completely rewritten, and distribution maps were added, to make the guide much more informative. $12.95 Canadian. The easiest way to get this is to order a copy from the museum gift shop, using your credit card. 604-356-0505.

Schuster, R.M. 1953. Boreal Hepaticae: A manual of the liverworts of Minnesota and adjacent regions. American Midland Naturalist 49: 257-679.

Reprinted by J. Cramer in 1977, as Band 11 of *Bryophyta Bibliotheca*, now out of print but in university libraries. Very useful for our area, excellent illustrations and discussions.

Schuster, R.M. 1966-1992. *The Hepaticae and Anthocerotae of North America*. 6 vols. Vols. 1-4 published by Columbia University Press, NY. Vols. 5 & 6 published by Field Museum of Natural History, Chicago.

One of the most remarkable works in the history of bryology, indispensable to any serious worker, perhaps overwhelming to the beginner. The smallest volume has 832 pages, the largest 1334! Schuster sets a very high standard of meticulous scholarliness coupled with exquisite illustrative skills. Note that the fine print on the title page says "East of the Hundredth Meridian" which means species restricted to the west are not covered. Most of our species are treated here (>85%). Unfortunately, such a massive work is expensive and, worse, partly unavailable. Volumes 2 and 3 are the two most useful for workers in the Pacific

Northwest. Order from Columbia University Press, 1-800-944-8648:

Volume 1: out of print, no reprint date.
Volume 2: $194.50
Volume 3: $127.50
Volume 4: out of print, no reprint date, highly sought after.

The final two volumes are available from The Field Museum of Chicago, (phone) 312-922-9410, ext. 402 or FAX 312-427-7269. Cost for the set is $290.00 + $5 shipping.

Vitt, D.H., J.E. Marsh, & R.B. Bovey. 1988. *Mosses, Lichens & Ferns of Northwest North America*. Lone Pine Publishing, Vancouver, BC and Edmonton, AB. ISBN 0-919433-41-3

This is the first decent photographic guide to PNW cryptogams. With over 400 generally good color photos, it was enthusiastically received and soon went out of print. It has recently been reprintedat $24.95. The first printing went for $17.50. Note that it is very good for lichens and mosses but poor with liverworts and ferns. Pojar and MacKinnon is better for these.